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1. Forwarding Address. Papers intended for publication in THIS JOURNAL should be submitted to Neil E. Gordon, Editor, The Johns Hopkins University, Baltimore, Maryland.

2. Manuscript. The manuscript submitted should be an original (not a carbon) copy, and typewritten, double-spaced, with 2–3 cm. margins. The title of the article should be followed by the name and address of the author. If the paper has been presented at a meeting, a footnote giving name of society, date, and occasion should immediately follow the author's name. The usual editorial customs, as exemplified in the most recent issues of the JOURNAL, should be followed as closely as possible.

3. References and Footnotes. Each reference to the literature and each footnote should be inserted without a number, as a separate line (or lines) immediately following the word to which it refers in the text. A reference to literature should include, in the order named, the title of book or article, author's name, edition or volume, pages, date of publication, and, in the case of books, publisher's name.

4. Illustrations. Not all articles lend themselves to illustrations, but articles which do should be accompanied by as many pertinent illustrations as possible. As a rule, apparatus, particularly if complicated, is best presented by means of line or working drawings. Photographs are sometimes sufficient, however. When both can be obtained, it is generally desirable to include both.

Photographs should have a gloss finish and should be at least post-card size—larger, if possible. Only prints which are unblurred and which show sharp contrast between light and dark areas can be satisfactorily reproduced.

Line drawings should be carefully prepared in black ink on plain white drawing paper or blue drawing cloth, twice or three times the size desired in the printed cut; it is convenient, when permitted by the scale required, to have them the size of the manuscript. When coördinate paper is used, it should be printed in blue only, with the important coördinate lines ruled over in black; the black square should in general not be less than ten millimeters on a side; the lines of the curves should be the heaviest, except the frame; points on the curves should be indicated by true circles, not crosses. The numbering of the coördinate axes, the number of the figure and any necessary explanations of the figure should be written in pencil in the margin of the sheet, as they are usually set up in type rather than reproduced from the drawing. All lines, numbers, and letters that are to be reproduced are to be so proportioned that they will be clearly legible in the cut.

Tables should be inserted in the body of the manuscript at the proper place.

All photographs, line drawings, and tables should be provided with self-explanatory titles or legends. Each illustration should be marked in pencil on the margin with the name of the author and the title of the article to which it refers.

Christian Friedrich Schönbein

EDITOR'S OUTLOOK

Chemical Education

IT HAS frequently been remarked, by ourselves and by others more able, that education is not necessarily, nor even chiefly, a formal process. The child has already been educated to a certain extent by the time he first sets foot inside a school; he should realize that his education is still incomplete when he receives his final degree. These facts are accepted by every one who has ever seriously considered education at all. There is perhaps no profit in reiterating them here, except that they lead naturally to the point which we desire to make, namely, that what has been so frequently emphasized from the learning angle is no less true from the teaching angle. Teaching is no more confined to the classroom than is learning.

Chemical education therefore is not preoccupied solely with classroom subjects and methods. Nor are professional teachers of chemistry the only ones to whom chemical education is a subject of vital concern. Every institution which awards degrees in chemistry might well include courses in chemical education as optional or required minors in its chemical curriculum. That statement may appear revolutionary to many of our readers and we are aware that it requires both qualification and explanatory amplification. In the first place such courses should be quite different from the typical education or methods courses generally offered by departments of education. Just what they should be like we shall not attempt to describe in detail here. Perhaps a general idea of their essential requirements may be indicated by a consideration of the facts which seem to us to point to their desirability.

By whom and under what circumstances is chemistry taught outside the classroom? We believe it must be conceded that every chemist who aspires to a position of leadership or responsibility in his profession must "teach" chemistry in one manner or another. One of the examples which suggests itself most obviously is that of the director of an industrial laboratory charged with the maintenance and training of a chemical personnel. He engages men more or less well grounded in the fundamentals of chemistry according to the nature of the work they are to undertake. Before they can attain their full value to his organization, however, they must usually receive additional training to familiarize them with the products, processes, and problems with which the organization deals. Whether that training be imparted incidentally as they proceed about their duties, or whether it be effected in part through special talks or formal lectures, the responsibility of conducting it, or at least of supervising it, rests upon the director of the laboratory. His aptitude in this phase of chemical education will have a significant effect upon personnel turnover and efficiency of operation within his department.

But the laboratory director's "teaching" activities do not as a rule end with his subordinates. It may be necessary for him to make frequent reports and recommendations to higher executives or to company directors who are not themselves chemists. The clarity of his reports and the force of his recommendations will depend upon his ability to do a little unobtrusive educating in their presentation. If it falls within the scope of his duties to confer with the advertising department or the representatives of an outside advertising agency concerning the preparation of technical copy or of general advertising of the type usually designated as "educational," his ability as a "teacher" is again at a premium.

If we pass to a consideration of the growing number of occupations not strictly chemical in nature but requiring chemical knowledge for their successful pursuit, it is evident that the teaching factor becomes even more prominent. The lawyer involved in a patent or damage suit arising out of chemical processes or products must not only know a certain amount of chemistry but he must be able to "teach" chemistry to a judge or jury. He can call upon consulting chemists for information and advice and he can employ expert witnesses, but unless he can master the chemistry involved and can so conduct the questioning of his witnesses as to convey an understanding of the matter to the court, and unless he can supplement their testimony, where necessary, by explanations and interpretations of his own, his case is but poorly presented. He must engage in chemical education.

The scientific journalist who takes a conscientious professional pride in his work, who is not interested solely in producing so many words at so many cents per word, who desires to create something better than mere propaganda or mild newspaper sensation, must be almost purely an educator. He must ponder the questions which confront any teacher. Just how can this subject be most interestingly and most simply presented? What analogies can I employ to clarify my presentation, without at the same time creating false impressions? How can I best convey an idea of the significance of the discovery I am describing both from the standpoint of the development of the science itself and its probable effect upon contemporary life?

These few illustrations will no doubt serve to make our point of view apparent. The question remains whether it is possible to produce "teaching" ability by training. If by this we mean—Is it possible to create an aptitude which does not exist?—the answer no doubt must be in the negative. If it is taken to mean—Can an aptitude already existent be cultivated and directed to greater effectiveness?—we must answer, yes, or else abandon our whole present educational philosophy.

THE STORY OF COPPER

J. W. HOWARD, STATE UNIVERSITY, MISSOULA, MONTANA

Historical

Since native copper often occurs at the surface, requires no smelting in its preparation, and is readily worked, it is but natural that it was known and used in prehistoric times. It is probable that copper ores were not reduced to the metallic state as early as iron ores. In opening the Lake Superior mines, however, excavations to the depth of sixty feet disclosed stone hammers and charcoal. At Ducktown, Tennessee, were also found remains of prehistoric smelting operations.

The alchemist symbol for copper was ♀ which also was the astrological symbol for the planet Venus. These early workers were attracted by the fact that copper is readily precipitated from solutions of its salts by iron and naturally regarded this as an evidence of transmutation of metals.

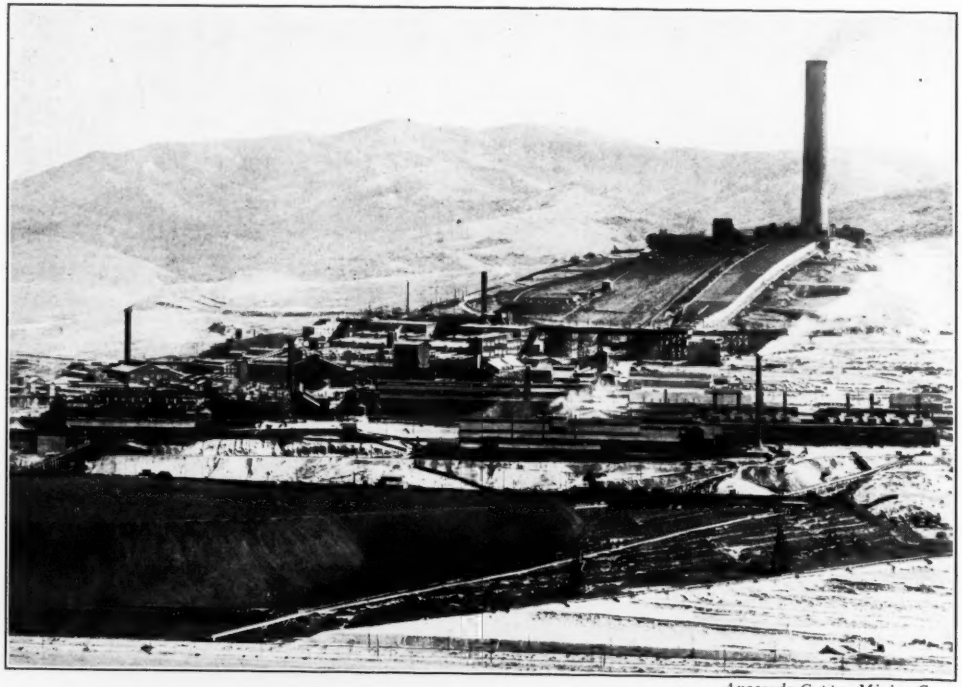
To the Romans all kinds of bronze and copper were known as *aes*. The pure metal they obtained from Cyprus under the name *aes cyprium*, which later became cuprum with the symbol Cu. Finally this was anglicized as copper.

As late as 1845 the whole output of copper in the United States was only 100 tons per year. This came from Vermont, Pennsylvania, Virginia, North Carolina, and Georgia. California became a producer in 1860, but the Lake Superior mines were the leading producers up to 1887, when they were outranked by Montana, where mining had started in the seventies. New Mexico, Arizona, and Lower California comprise a great copper district, along with Nevada and Utah, which were the last to enter the list as important producers. Enormous deposits have also been opened up in Chile.

It is of interest to note that gold was the lure which attracted the miners to the Butte, Montana, deposits. The prospectors soon turned from gold to the silver-bearing quartz veins and from silver to copper. The final result is that the mines have yielded hundreds of millions of pounds of copper per year and only small amounts of silver and gold. Hence the saying: "A man is likely to go to the poor house with a gold mine on his hands, may make a fair living from a silver mine, but easily becomes wealthy when he finds a good copper mine."

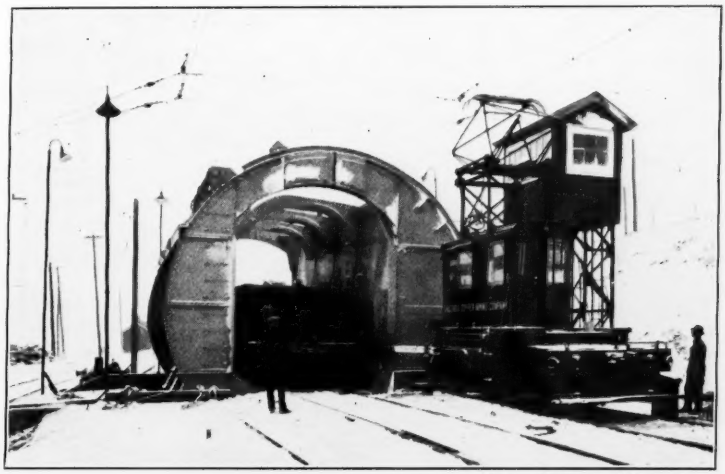
For many years the city of Swansea in Wales was the world's chief center of copper smelting, the ores from the western states being shipped there for treatment till 1885.

It is also historically significant that electrical engineering with its use for very large amounts of copper commenced its greater development at about the same date as that of the copper industry, and that the copper industry has in turn benefited by use of electric machinery and the electrolytic method of refining.



Anaconda Copper Mining Co.

GENERAL VIEW OF SMELTER AT ANACONDA



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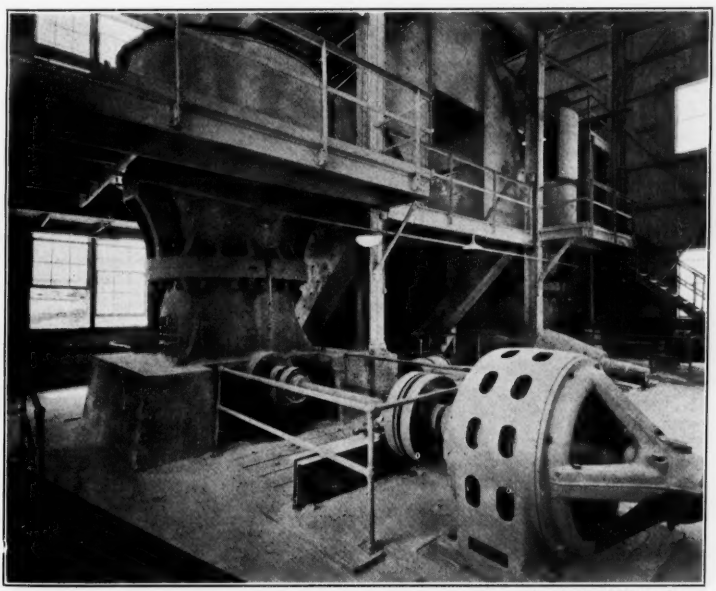
ORE CAR IN ROTARY CAR DUMPER



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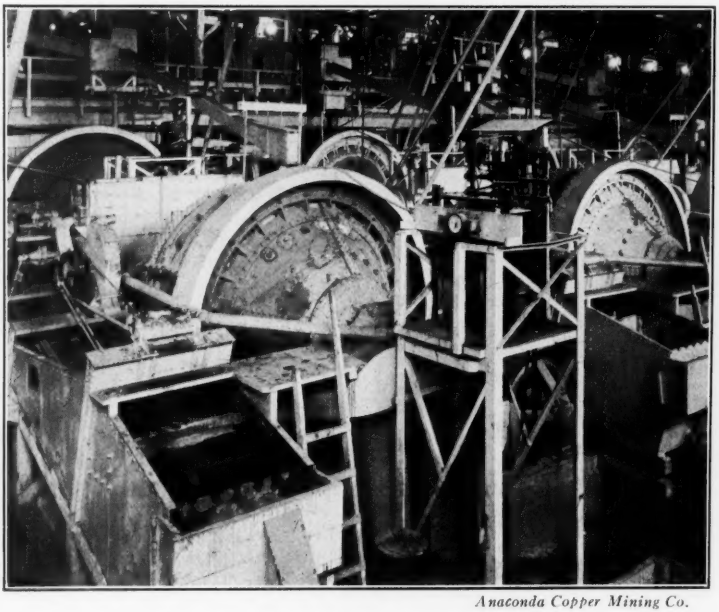
GYRATORY CRUSHERS

Occurrence

Copper occurs in nature chiefly as sulfide and oxide ores and as native copper, each type requiring a special metallurgical process for concentration and refinement. The sulfide ores are chalcocite, Cu_2S; covellite, CuS; bornite, $3Cu_2S \cdot Fe_2S_3$; energite, $3Cu_2S \cdot As_2S_5$; chalcopyrite, $Cu_2S \cdot Fe_2S_3$; tetrahedrite, $4RS \cdot Sb \cdot As_2S_3$, where R may be Cu, Fe, Zn, or Ag_2 and will run 15–48% Cu; tennanite, $4Cu_2S \cdot As_2S_3$. The leading deposits are in Montana, Utah, Nevada, California, and the Atlantic coast beds. The most prominent sulfide minerals economically have been chalcocite and



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DORR CLASSIFIER AND HARDINGE BALL MILLS

chalcopyrite. The oxide ores are cuprite, Cu_2O; tennorite, CuO; malachite, $CuCO_3 \cdot Cu(OH)_2$; azurite, $2CuCO_3 \cdot Cu(OH)_2$; chrysocolla, $CuSiO_3 \cdot 2H_2O$; atacamite, $CuO_2 \cdot 3Cu(OH)_2$; brochantite, $CuSO_4 \cdot 3Cu(OH)_2$ and chalcanthite, $CuSO_4 \cdot 5H_2O$. These ores occurred abundantly at one time in the southwest, especially in Arizona where in a number of places mining has now gone below the oxidized into the sulfide zone.

Native copper occurs in the upper peninsula of Michigan disseminated through amygdaloid and conglomerate beds of eruptive rocks. The rock averages about 1% copper. The native copper itself is very pure, running

99.92% copper with traces of silver, iron, nickel, and arsenic. A single mass found in one of these mines weighed 500 tons.

Traces of copper are also found in the feathers of certain birds. In the blood of the cuttle fish copper plays the part which iron plays in the blood of mammals. It is also found in the blood of oysters, lobsters, and scorpions. Chocolate and cocoa contain one part copper in 100,000 parts by weight.

Process for Sulfide Ores

These ores require a much longer process of concentration than the oxide ores or native copper. The process used may be briefly outlined as follows:

Courtesy of Anaconda Copper Mining Co.

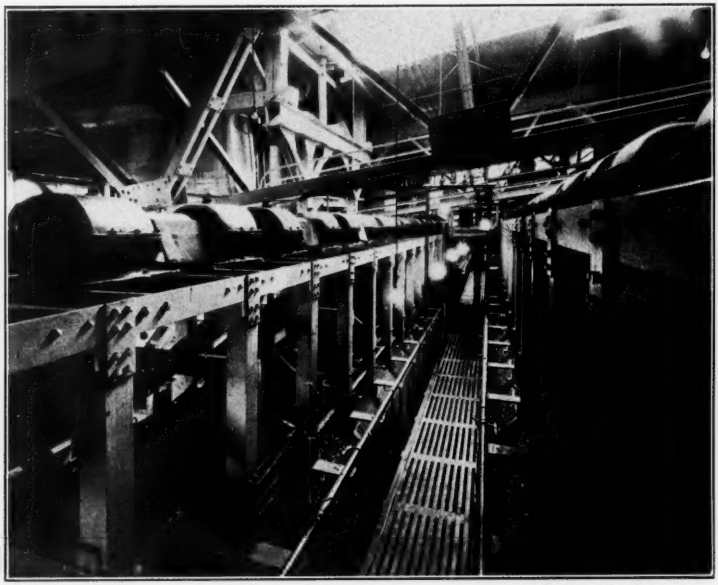
ANACONDA CLASSIFIERS

ORE IN CARS → STORAGE BINS → CRUSHERS → ROD AND BALL MILLS → CLASSIFIER → FLOTATION MACHINES → OLIVER FILTER → ROASTER → REVERBERATORY FURNACE → CONVERTER → REFINING FURNACE → ANODES → ELECTROLYTIC REFINING → CASTING FURNACE.

The ore as received from the mines ranges in size from dust to pieces as large as can be conveniently mined. The crushers reduce the larger material to a maximum of 2 inches in diameter. It is then passed through rod and ball mills to reduce it to sufficient fineness for flotation. The classifier removes all that is still too large and it is sent back to the ball mills for further grinding. The pulp or slime which comes from the classifier is usually about 20% solids and is ready for the flotation machines.

Flotation

In flotation we have what may be aptly called an upside-down process, the heavier metals are made to rise while the lighter minerals sink. This is brought about by taking advantage of the fact that when certain oils are mixed with the ore, they stick to the metallic minerals but do not attach themselves to the non-metallic ones. This selective action is aided by the addition of small amounts of so-called flotation agents as xanthates, mercaptans and acids. Vigorous agitation of a mixture of water, ore, oils, and agents beats air into the mass, resulting in a persistent froth of air bubbles so light that it can support the fine mineral particles that adhere to the oil.



Anaconda Copper Mining Co.

FLOTATION MACHINES

The oil used is usually a mixture of a "collector" as coal tar and creosote and a "frother" as pine oil. The relative amounts and kinds used must be determined by experiment for individual ores.

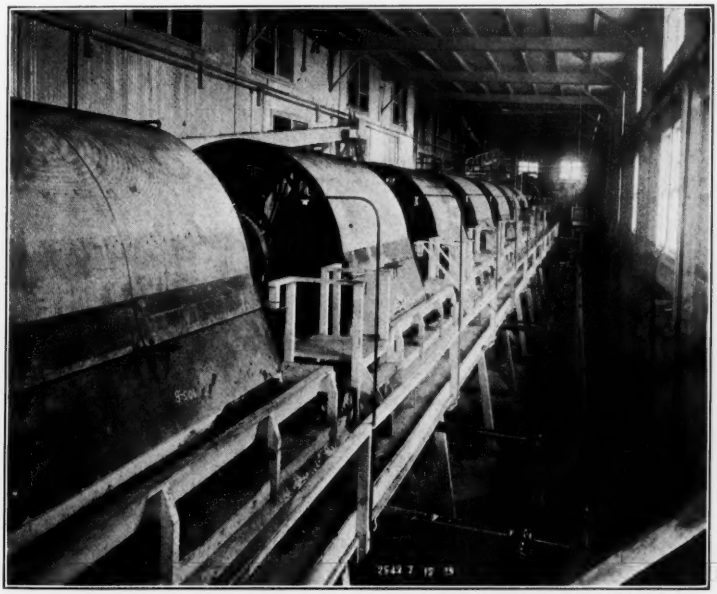
The various flotation processes differ in the mixtures used and in the mechanics of handling the froth. The froth must be of sufficient stability to hold the minerals till it passes over the edge of the machine and then quickly die away. As the froth subsides, the water is removed in turn by Dorr thickeners and Oliver continuous filters.

Ninety-five per cent of the copper is saved by these concentration proc-

esses while nearly two-thirds of the ore is discarded, the credit being chiefly due to flotation. Flotation has also practically eliminated the blast furnace as a smelting operation for the copper sulfide ores. It has been found more economical to grind all the ore to the impalpable condition of clay necessary for flotation than to treat the larger pieces in a blast furnace.

Roasting

The object of this process is to burn out part of the sulfur and to oxidize a part of the pyrite to FeO. This enables part of the iron to go into the



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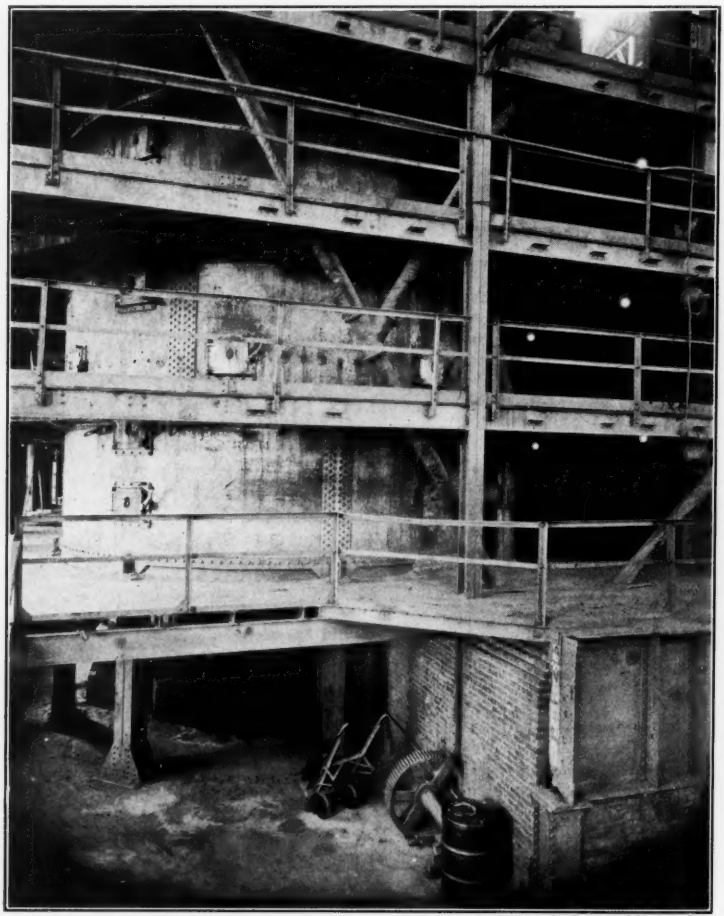
OLIVER FILTERS

slag and hence reduces the amount going into the matte in the reverberatory furnace.

The operation is conducted at red heat, yet below a fusion temperature. The McDougal type of furnace is most generally used. It is a cylindrical type with several hearths one above the other. The ore, automatically fed to the top hearth, is moved from circumference to center by two rabble arms which are attached to the central shaft, and drops through an opening on to the next hearth across which it is similarly moved to the circumference. The stirring action of the rabbles constantly exposes fresh sur-

faces of the charge to the hot gases coming up from the lower hearths. A furnace of 23 feet inside diameter can handle 125 tons dry weight of flotation concentrate in 24 hours, removing 12% moisture and reducing the sulfur



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ROASTING FURNACE

content from 33 to 8 or 9%. The product is known in the works as "calcine."

The latest practice seems to be to burn out less sulfur than that indicated or to use the roaster for drying purposes only, due to the higher grade of

concentrate produced by flotation. This is a good example of the change in operation which one finds in an up-to-date reduction works as a result of research.

Reverberatory Smelting

Further concentration is accomplished in the reverberatory furnace. This is a large chamber made of silica brick thoroughly braced with steel buck stays. Some of the larger ones are 27′ wide and 144′ long. Iron pipes are built into the arched roof through which the charge is introduced into the furnace. Heat may be obtained from the burning of powdered coal which is blown into one end of the furnace by an air blast. This burns like a gas flame, transmitting heat by radiation from incandescent carbon par-

Anaconda Copper Mining Co.

REVERBERATORY FURNACE, SHOWING FIRING END WITH COAL DUST BURNERS

ticles, the products of combustion passing away at the other end of the furnace. Many plants use oil in place of the powdered coal.

The charge is chiefly calcine mixed with dust from other departments and caught in the flues, chemically consisting of a mixture of sulfides of copper and iron with silica, alumina, and lime. The silica is put in to form a slag with any iron oxide (FeO) formed and the lime to make this slag more fusible.

The other product of the reverberatory furnace is known as "matte." It is an artificial sulfide of about 23–25% sulfur. A small amount of sulfur is burned out due to local excess oxygen, and the excess sulfur in FeS_2 is distilled off if it has not already been roasted off. About 90% of the sulfur

of the charge goes into the matte. The sulfur combines first with copper and any remainder or excess (a deliberately calculated excess) combines with the iron to go into the matte. Any excess of iron will then be in the form of FeO and combine with the silica in the form of slag. In some works the matte runs about 42–45% copper. It carries with it also any precious metals (gold and silver) present.

As the matte has about twice the specific gravity of the slag it settles to the bottom of the molten mass, making it easy to separate from the slag by tapping at the proper levels. The slag is run into a stream of water which granulates it and carries it to the dump or it may be collected in ladles and taken to the dump. If by accident some of the matte would also flow into this stream of water it would react with explosive violence. The matte is tapped into immense steel ladles and taken to the converters.

The flare of the slag stream is a striking sight at night as one watches the skimmer with his hoe-like rabble bending back and forth, helping the slag to flow out and "pulling" until the iron rabble gets too hot to hold its shape. He is entitled, then, to pull it out and rest while the next skimmer carries on.

One hundred tons of charge of 9% Cu will yield 24 tons of matte and 67 tons of slag.

Converting

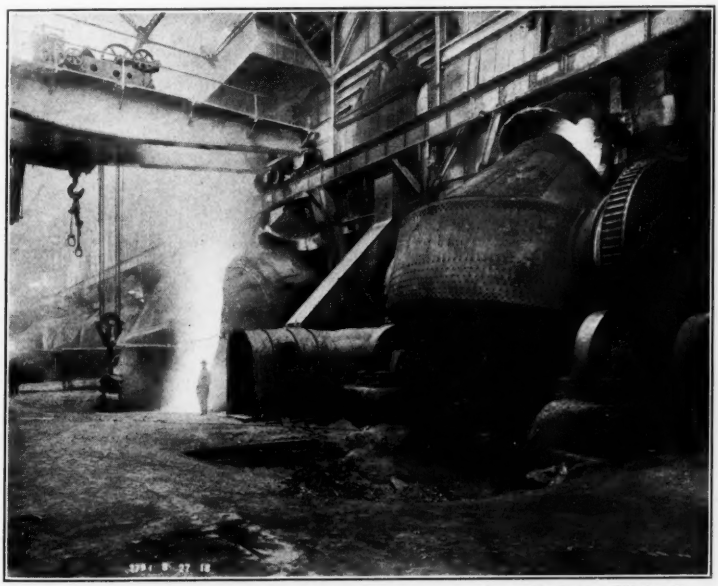
This process is the last stage in the series of eliminations that finally leave metallic copper.

The average converter is a large cylinder topped with a truncated cone, the upper end being open to receive charges and to act as an outlet for gases, although they vary widely in shape and capacity. It is made with a heavy shell of steel plate, thickly lined with magnesia brick. The inside dimensions of one type are a diameter of 16 feet and a depth of 15 feet. At the back and near the bottom a line of tuyère pipes admit compressed air. Two pairs of huge steel rollers on massive foundations act as supports.

Into the type of converter described is poured a 65-ton charge of molten matte from the reverberatory furnace. Air at 16 lb. pressure to the square inch is blown through the liquid mass, burning the sulfur to SO_2 and the iron to iron oxide. The iron oxide combines with the silica and alumina of the raw ore that is added to supply these slag-forming substances. At intervals the converter is turned to pour out this slag. The process as a whole is considered the most spectacular in the reduction works. Flames of varying color are seen belching from the throat of the converter, changing to a permanent blue as the iron oxidizes. Whenever the converter is turned to pour off slag or copper the contents have the appearance of liquid fire. One is also struck here by the skill of the "tuyère punchers" behind the converters lunging head down with their iron bars at the valve

pipes about $1\frac{1}{2}$ or 2″ diameter. They drive through past the rolling valves, hitting fifteen or twenty of these one after the other without looking and without missing. After all of the iron has been slagged a copper sulfide of about 78% copper is left. Further blowing removes the sulfur, leaving the copper alloyed with silver and gold.

A 65-ton charge of matte requires three hours to slag the iron and another one and three-quarter hours to convert the copper sulfide to copper.



Anaconda Copper Mining Co.

GENERAL VIEW OF CONVERTER FLOOR
First converter in blowing, second in pouring position.

Refining

As it is impossible to separate completely the copper and slag by the pouring method of the converter, further refining is necessary. The furnace in which this is done is similar to but smaller than the reverberatory furnace. An iron pipe carrying air under 16 lb. pressure to the square inch is pressed below the surface of the liquid copper. The air and sulfur combine, leaving the furnace as SO_2. The iron is oxidized and slagged and any arsenic, antimony, lead, zinc, etc., present is also slagged or oxidized into fume. As this slag is very rich in copper it is returned to the converter.

The air, however, also oxidizes some of the copper. This is reduced back to the metallic state by forcing green poles beneath the surface of the

charge. The refiner determines when the copper has come to the right "pitch" for removal by observing the surface of small cooled samples in a little iron cup.

The copper flows from the furnace into cast iron molds, which are carried on a chain conveyor through a tank of running water, and ejected as anodes. At this stage of a trip through a works one feels that he has observed noise, fumes, and flare until it is hard to decide whose forces man is using most in these operations, those of God or of the Devil.

Dust Recovery

The drafts of the different furnaces cause a certain amount of dust loss. As this dust has considerable metal value some scheme had to be devised

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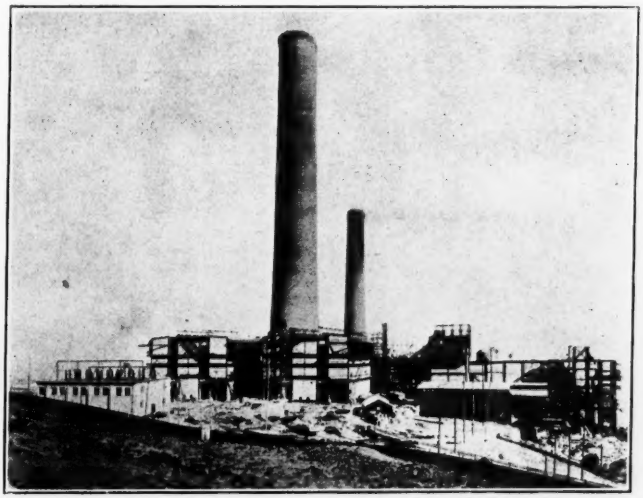
POURING ANODES FROM REFINING FURNACE

for its recovery. In most cases this is done by passing the gases first into large brick chambers where the coarser material settles. From here it passes through brick flues generally $20' \times 15'$, and finally goes to the main stack. The entire collection of dust is mixed with the charge going into the reverberatory furnace. The main stack is a massive structure and an outstanding landmark in the copper country. The one at Anaconda, for example, is $585'$ high, with an inside diameter of $75'$ at the bottom and $60'$ at the top and with walls varying in thickness from $2'$ to $6'$.

When the copper ores carry traces of zinc and arsenic, which form very volatile oxides, the flue and stack system as described may not catch all the dust. The fine condition of the flotation concentrate has also tended toward large dust losses. Hence, it has been found advantageous in many

plants to equip the stack with Cottrell Precipitation apparatus. Sheets of corrugated roofing steel have been hung in box-like chambers in the bottom of the stacks. These sheets are 12″ apart and between them are rows of small chains at 5″ intervals. The chains carry a static charge of electricity at a tension of 62,000 volts. As the gases rise between the plates the particles of dust and fume become electrically charged and are repelled from the chains to the plates. The particles then discharge their electricity through the plates, which are grounded, the dust collecting in masses of sufficient size to fall through the rising current of gas.

In many plants the SO_2 of the fumes is used to make sulfuric acid, which is subsequently used for their leaching and electrolytic proc-



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COTTRELL PRECIPITATORS AT ANACONDA

esses. Some of the Tennessee plants originally made sulfuric acid to cut down the smoke nuisance, but now find it very profitable for use in treating phosphate rock for fertilizer manufacture.

Electrolytic Refining

Despite the careful system of refinement and concentration the anodes are not absolutely pure copper. The composition will vary with the nature of the ore and hence the locality, but the following analysis, reported as an average by the Great Falls Refinery, will give some idea of the purity:

Per cent Cu	99.3
Oz. Ag per ton	67.0
Oz. Au per ton	0.3
Per cent As	0.085
Per cent Sb	0.04

For further refining the electrolytic method is used. This may be done by one of two systems. In one, known as the multiple system, all the anodes in a single tank are connected in parallel; the cathodes are similarly connected and then a large number of such tanks are connected in series. This allows the flow of a heavy current at low voltage through each unit.

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A COPPER REFINERY SUB-STATION

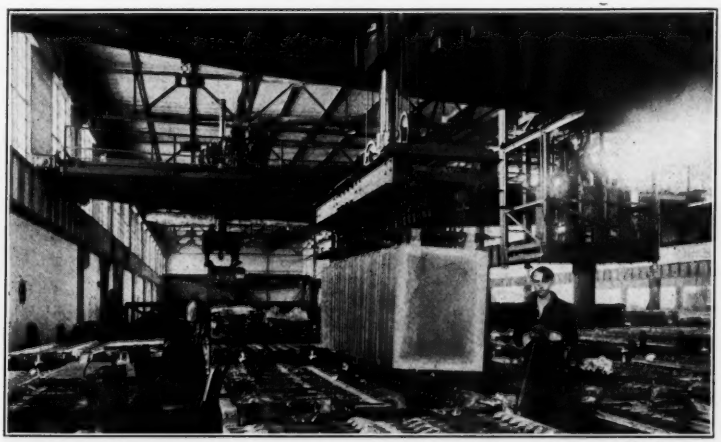
In the other, known as the series system, each tank is filled with bi-polar electrodes, from one side of which crude metal dissolves, which deposits on the other side. This system uses less current but greater voltage than the multiple system. The multiple system has practically replaced the series system in the refineries.

The tanks are wood lined with 6% antimonal lead and vary greatly in size. A tank 10′3″ × 2′10″ × 3′9″ deep will carry 25 anodes and 26 cathodes. An anode of dimensions 36.5″ × 28″ × 2″ will weigh about 630 lb. The cathodes are made of pure rolled copper 1–2 mm. thick and of about the same dimensions as the anodes. Some prefer them a little larger as this tends to reduce "teeing" on the edges.

The electrodes can be suspended in the tanks by lugs, or by laying cross bars over the tanks and suspending the electrodes by hooks, loops, or clips. The latter method allows more energy losses due to more contacts, but does not leave as much unattacked electrode after electrolysis.

The electrical energy is furnished by generators which deliver 10,000 amperes at 210 volts, equivalent to a current density of 26.4 amperes per square foot of cathode area.

The electrolyte generally contains 3–4% copper as $CuSO_4 \cdot 5H_2O$ and 10–13% H_2SO_4. Often a little NaCl, $MgCl_2$, or HCl is added to aid in the precipitation of the precious metals, although an excess of chlorine ion must be avoided as it may cause nodules of Cu_2Cl_2 to form on the cathodes. Small



Anaconda Copper Mining Co.

VIEW IN ELECTROLYTIC REFINERY, SHOWING CATHODES WITHDRAWN FROM TANK (GREAT FALLS PLANT)

quantities of glue and gelatin are said to improve the physical character of the deposit. The electrolyte enters at about 60°C. and leaves at 50°C., being kept in constant circulation.

The anode remains in an average of 24 days during which time four drawings of 6-day cathodes of 130–140 lb. each are made. About 7% of a non-lug and 12.5% of a lug anode is left to be cleaned and sent to the furnace for re-melting and casting.

During the process the electrolyte steadily deteriorates. The H_2SO_4 is gradually neutralized and impurities accumulate which might deposit on the cathode. The $CuSO_4$ concentration generally increases. For this reason part of the electrolyte is daily diverted and sent through a purification plant. Here the electrolyte may be sent through a series of insoluble

anode tanks, where the copper is electrolyzed out in the first tank or two and sludges rich in arsenic are obtained in succeeding tanks. On evaporation of the remaining liquor other insoluble sulfates crystallize out, leaving H_2SO_4.

Another scheme is to crystallize out the Cu as $CuSO_4 \cdot 5H_2O$ and work the mother liquor up for the other metals present.

The other product of electrolysis is the slime which falls to the bottom of the tank. It may contain fragments of Cu, Ag, Au, Pt, S, Se, Te, Bi, and Sb salts, $PbSO_4$, AgCl, Cu_2O, and arsenic oxides; proportions vary greatly, the copper alone running 11 to 50%.

The copper is first removed from the slime as the sulfate, being converted

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CHARGING FLOOR OF CASTING FURNACE

Cathodes are shown on trucks in background and barred doors of furnace in foreground.

into this by the combined action of air and H_2SO_4. The residue is then fluxed and oxidized by air. In this way Sb, Pb, As, Bi, Se, and Te are either slagged or volatilized. After further oxidation with nitre, Cu, Ag, Au, and possibly Pt remain. These are separated by various metallurgical processes.

While electrolytic copper is very pure, the cathodes must be re-melted and cast into suitable shapes for use in the wire mills or in the manufacture of alloys. This is done in a reverberatory type furnace, the cycle of operations being charging, melting, oxidizing, poling, and casting, the whole being completed in a 24-hour period. The resulting product averages 99.955% copper.

Chemical Control

A modern copper reduction works has both a general chemical laboratory for control work and a research laboratory for the study of improvement of present processes and better working-up of by-products.

The division of work in the general laboratory would naturally differ in different works. The following statement to the author from a chemist in one of the works will give a very good idea of the type of work in the general laboratory. "One man runs about 40 irons, 35 cyanide coppers, 30 insolubles, and 2 or 3 sulfurs a day. We also run coals, oils, etc., as well as golds, silvers, electrolytic coppers, and complete analyses on slags (Fe_2O_3·Al_2O, CaO, MgO, SiO_2) plus colorimetric coppers. Most copper samples are run by the electrolytic method and three men turn out about 150 a day. Rotating anodes are in general use for this latter determination and results must check within 0.02%. I find the chief requirements for the work are common sense, intelligence, and careful speed."

It might be added for the encouragement of the "quant" student who puts in several hours on one determination, that he is not expected to arrive at the laboratory with this speed all developed, but he must be capable of acquiring it. Further he will find everything organized in the laboratory to help him speed up his work. In many plants, men are selected from the laboratory to supervise processes in the plant.

Smelting of Oxide Copper Ores

These ores, when rich in copper, were formerly smelted in water-jacketed blast furnaces, yielding as products slag and black copper (96% Cu). At present the practice is to mix them with copper sulfide ores and carry through the regular sulfide process of reduction. If poor in copper, the oxide ores are leached, which process will be described later. Many of the copper companies are working on new methods for oxide ores. If a method could be devised for handling oxides as successfully as flotation for sulfide ores it would be a great boon to the copper industry.

Smelting of Native Copper Ore

The ore as it comes from the mine is called "mass" and runs about 70% Cu. It first passes through an ore dressing works where it is crushed into the following grades: *barrel work*, consisting of pieces of orange size and smaller; *headings* made up of egg size; *grades* consisting of material from slime to walnut size. The proportions of these products depend on the ore and individual works practice.

The process of smelting is an oxidizing fusion in a reverberatory furnace, with or without the addition of limestone to act as flux, the products being slag and copper.

Leaching

This process is used chiefly on low grade oxidized ore and old tailings. Before flotation came into general use the tailings ran about three times as high in copper as at present. While the copper went into the tailings as sulfide, much of it is oxidized on long standing and would be directly soluble in the leaching agent. If the tailings are of more recent origin, the general practice is to roast them, converting all the copper into oxide before applying the solvent.

The solution part of the process is carried on in vats of tarred or lead-lined wood, acid-proof bricks or asphalt concrete. Matting is laid on the bottom through which the solution is filtered, after the copper has gone into solution.

The most widely used solvent is dilute sulfuric acid containing small amounts of salt. Other solvents in use are hydrochloric acid, sulfurous acid, ferric sulfate, ferrous chloride, and ammonia. The copper is recovered from solution by electrolysis or precipitation by metallic iron. The physical nature of the precipitated copper varies with the type of iron used, but in practice the cheapest scrap iron available, including the tin can, serves the purpose. The precipitation is carried out in a series of concrete tanks. While iron displaces 90–98% of the copper present, and is itself largely dissolved, part of it rusts and mixes with the copper. The resulting dried product thus obtained is only about 60% copper and is mixed with the charge in a reverberatory furnace for final recovery.

The electrolysis method of recovery is used in several large plants. Insoluble anodes made of special alloys are used with consequent regeneration of the leaching agent.

The precipitation part of this process is also used on mine waters which contain in some cases as much as 0.05% copper as soluble salts. This water is run through long flumes filled with old iron or through towers which are equipped with wooden stringers carrying iron.

Properties

Among the properties of copper the following are selected as being of chief interest: specific gravity at 20°C.—8.89; m. p.—1083°C.; b. p.—2310°C. With iron at 4.5 and silver at 2.7 the scratch hardness is 3.7. The color ranges from orange-red to rose color, the shades depending on the temperature of the cooling water in which it was quenched. It soon acquires the familiar copper color on exposure to air. In very thin films it is transparent, transmitting greenish to bluish light. The tensile strength of the cast metal is 60,000–70,000 lb. per square inch. This is reduced by annealing. It is easily rolled into sheets, hammered into foil, or drawn into fine wire. As mechanical treatment hardens it, the copper

can be restored by annealing it at 500–700°C. in an atmosphere free from sulfur. Pieces are easily joined by electric welding.

It is one of the best conductors of heat and electricity, and the best for electricity if the item of cost is considered. Small amounts of impurity greatly affect its conductivity. Traces of iron make it more brittle.

It is readily soluble in dilute HNO_3; aqua regia; boiling H_2SO_4 of 66° Bé.; slowly, in hot dilute H_2SO_4; in NH_4OH in presence of air; and in dilute HCl with air.

Uses

Because of its inactivity with water, many acids, and steam, it is used in a variety of manufacturing industries, and as a covering for houses and ship bottoms. It is also used in making plates for printing and engraving. Its use in electrical work is everywhere apparent.

No other metal is so extensively used in the form of alloys as copper. Brass, age old in use, is of varied composition. It is generally $^2/_3$ copper plus $^1/_3$ zinc, but may contain some tin and lead. It is harder and stronger than either copper or zinc and works much better in a lathe or cutting machine. It is considered much better, because of its longer life, for use in place of galvanized iron piping for general plumbing purposes. Copper coins are usually alloyed with 3% tin and 2% zinc. Gold and silver coins contain 10% copper. Nickel coins are 75% copper and 25% nickel. Gunmetal, bell metal, and bronze are copper and tin, although some zinc or lead may be present. Manganese alloys with copper have quite varied uses. German silver is 57% copper, 19% zinc, and 24% nickel. An aluminum bronze containing 95% copper is very strong and light. It may be safely said that it is more generally used than any other metal save iron.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Junior Technologist. Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than April 9th. The entrance salary is $2000 a year. Higher salaried positions are filled through promotion.

The examination is to fill vacancies in the Bureau of Standards, Department of Commerce; in the Geological Survey, Department of the Interior; and in positions requiring similar qualifications, for duty in Washington, D. C., or in the field.

The optional subjects are (1) ceramics, (2) paper technology, (3) petroleum technology, (4) rubber technology, (5) textile technology.

Competitors will be rated on general chemistry, elementary physics, mathematics up to and including calculus, and practical questions on each optional subject chosen.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

CHRISTIAN FRIEDRICH SCHÖNBEIN. PART I. LIFE AND CHARACTER

RALPH E. OESPER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

It is a noble ambition to endeavor to fill the short span of our lives with deeds of lasting value. To a truly noble nature, there is no thought less endurable, yea, more repulsive, than to vanish utterly from the scene of life leaving no trace of useful accomplishment, to depart from this world without having contributed to the capital of the higher assets of humanity, to be physically alive and mentally dead, and to be forgotten by his contemporaries as soon as his eyes are closed.

Thus Schönbein summed up the creed by which he ordered his life. A simple, naïve man; a refreshingly candid character; a plain product of the common people, yet not afraid to associate with the great of his world; deeply religious yet not bigoted; a lover of nature and truth, an enemy of sham and show; a pioneer and yet a conservative; a keen, flexible intelligence exhibiting almost stupid stubbornness at times; a lover of peace, yet gladly bearing arms for a cause he deemed righteous; a model son, husband, and father; a keen-sighted investigator, yet almost blind in business affairs; he was all these things and more. "Unconventional, of unspoiled, original freshness," was Ostwald's characterization of this unusual personality whom Färber has aptly called the "Scheele" of the 19th century.

Christian Friedrich Schönbein was born October 18, 1799, at Metzingen, Swabia. Although his father was a dyer by trade, we cannot ascribe the boy's chemical talents to inheritance, for the father was so lacking in initiative that he lost his business and entered the postal service. The school facilities of the small town were limited and the questions of the active-minded boy soon led the teacher to advise Christian's father to provide better instruction for him. However, the finances of the family of eight children would not permit a lengthy period of schooling for the first born, and after being confirmed at Easter, 1813, Christian was apprenticed in a chemical and pharmaceutical factory at Böblingen, several hours' journey from his home. He suffered terribly from homesickness and his first manuscript was a poem in which he poured out his longing for his loved ones and the familiar landscape. This love for the land of his birth never left him, for many years later (1865) he wrote,

In spite of long absence from my home country, there still remains in me a considerable portion of Swabian, which feels the need of occasionally breathing native air, of eating sauer kraut, blood sausage, and dumplings, and of drinking Neckar wine; certainly no one can blame me for this.

The factory operations involved the preparation of a wide variety of chemical products and the establishment also included a teaching labo-

ratory in which the apprentices were given instruction in chemistry and physics. Besides acquiring a knowledge of theoretical and applied chemistry, Schönbein studied Latin, French, English, philosophy, and mathematics, and so well did he utilize the opportunities both in and outside the factory walls, that in 1820 he voluntarily asked Kielmeyer, professor of chemistry at Tübingen, to examine him. This examination, the only one to which he was ever subjected, was passed with great credit, and Schönbein felt competent to undertake a position offered by J. G. Dingler of Augsburg. The latter, a chemical manufacturer, was just starting his *Polytechnisches Journal* and evidently expected the new assistant to aid him in this venture, for he demanded "a chemist fitted for scientific rather than for the ordinary daily chemical affairs; he should be somewhat more than barely acquainted with chemistry in order that he can take charge of the analytical work. Furthermore, he should have a knowledge of languages, and at least be able to translate from the French." The salary offered was 200–300 florins per year (1 florin = 40¢) plus board and lodging. The working hours were from 6 A.M. to 7 P.M. but Schönbein devoted the time from 4 to 6 in the morning and from 7 to 10 in the evening to his private studies, paying particular attention to Berzelius' text which had just appeared in German translation. He also made good use of his employer's exceptionally large library of periodicals, and spent some time on languages and philosophy.

A resolve to abandon practical chemistry in favor of a scientific career gradually developed, and in August, 1820, he gladly accepted a position in a chemical factory near Erlangen, with the hope that proximity to a university might enable him to become acquainted with the faculty either through mutual acquaintances or by direct solicitation. It is quite characteristic that he did not hesitate to write to Prof. Schelling, the most famous philosopher in Germany:

> It is obvious that your philosophy, to me synonymous with a study of truth and so distinguished by originality, must be of intense interest to me and consequently I have the greatest desire to become acquainted with it. The most direct way would be to attend your lectures, but my present condition makes this impossible, so I know of no other way than to respectfully request that you impart your philosophy to me in the manner least laborious to you.

The appeal was granted; Schelling and his young admirer had long conversations and the intimate friendship that developed lasted to Schelling's death in 1854. Schönbein's employer, J. N. Adam, was so impressed with the young man's earnestness, that he not only released him from his contract, but made him private tutor to his children, so that Schönbein had not only time but funds to enter the university in May, 1821. Chemistry was taught by Kastner whose limitations were so soon discovered by

Liebig. The latter was at Erlangen during Schönbein's stay, but the two had little or nothing to do with each other, and only after many years, when they both had made names in the scientific world, did they become intimate friends. After one semester, Schönbein migrated to Tübingen, but found the offerings in natural science and philosophy extremely meager. His diary reveals that he took an active part in student life and his outstanding ability to make friends soon made the "noble Swabian" a prominent figure in the academic community. February, 1823, found him again enrolled at Erlangen as *philosophæ et rerum physicarum studiosus*. Much of his attention was devoted to philosophical, educational, and psychological problems, for the resolve to devote himself to teaching had become definite.

Friedrich Froebel, who later became famous because of his kindergarten movement, had started an educational community at Keilhau, Thuringia. Much of the class work was done in the woods and fields, for both teachers and pupils studied nature at first hand. Utmost simplicity in food, lodging, and clothing was a basic concept of the cult, the poverty of all members of the enterprise was accepted as a virtue, and monetary considerations were disregarded whenever possible. In the fall of 1823, Schönbein came into this curious environment as teacher of chemistry, physics, and mineralogy and for a time fitted in well. He wrote to his father in March, 1824,

> I could not wish for a better place than my present position. Teaching has now become a necessity to me. Your first inquiry will doubtless be about my salary, but on this point I can give you no information, for conditions here are such that this topic has not been discussed as yet. You know well that money is not the first of my desires, and so you will not be surprised to learn that I have not uttered a word on this subject to the director. In due season, I shall let you know what is necessary.

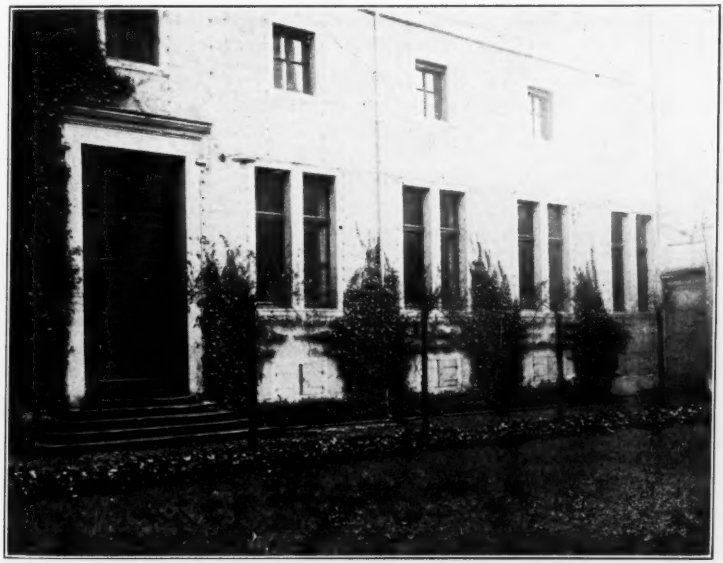
Translations from the French and English for scientific journals brought him some income. However, his fundamental common sense and ambition, to say nothing of breakfasts of hard pears, black bread, and water, soon overcame his original enthusiasm for Froebel and his school and although such an experience was perhaps necessary for him to get his feet on the ground, he was glad in January, 1826, to take a position in a boys' school at Epsom, England, where he taught mathematics and natural philosophy. He was very happy in his English environment and gave entire satisfaction, for he obtained leave to spend some time in London in order to attend courses of lectures on various scientific subjects. Among others he heard Faraday, with whom he did not become acquainted until much later. In recalling this first contact, Schönbein wrote to Faraday:

> ...being then rather a shy and bashful young man, I did not venture to enter into conversation with you in spite of my inclination to do so, and though I had, after the lecture was over, a favorable opportunity to speak to you.

Faraday wrote to him, "You cannot think how much each letter of yours tantalizes me, for they all make me wish I had known you sooner." After a short return to Epsom he went to Paris. In a letter to his father he wrote:

> My stay here is partly to master the French language, but especially to visit the scientific institutes which are the best in the world and therefore essential to my purpose. I hope to find some tutoring to ensure my living.

The lectures of Gay-Lussac, Thénard, Ampère, Dumas, the libraries, the museums gave him the greatest pleasure and instruction, but yet he hated



Schönbein's Laboratory and Lecture Room, University of Basel
Now forms part of the museum and houses the ethnographical collections.

the city and its coldness toward the young stranger. He was defrauded of most of the fees due him for tutoring; a translation of DeQuincey's "Opium Eater" was published without credit or reward, and his journey back to England became a return to a haven of comfort. Hardly had he become settled than he received an offer to act as substitute for Peter Merian, professor of chemistry and physics at the University of Basel. This temporary arrangement, due to Merian's illness, became permanent. The doctorate was conferred in 1829, and a full professorship of chemistry and physics in 1835. In 1852 a special chair of physics was created and Schönbein was relieved of instruction in this branch. Forty years were

spent in this school and all his scientific work was done in its modest laboratory.

Civil strife between the city and canton was brewing when he came to Basel, and at times it flamed into armed conflict. Schönbein bore arms with his fellow citizens and was later rewarded for this and other civic services by being made an honorary citizen. He served in the city council and in the cantonal assembly. In his politics, as in his science, he was conservative, combating all unnecessary changes but championing the right of free speech and thought. His mode of life was quiet and regular, broken by occasional journeys to visit friends or scientific gatherings. He was an inveterate letter writer and among his regular correspondents were Faraday, Grove, Berzelius, Liebig, Wöhler, and Pettenkofer. "Before I realize it, the page is full" occurs often in his letters, and one of his pet aversions was a blank space at the end of a letter. His forte was geniality and he cultivated the act of getting along with his associates. He wrote to his daughter:

> In general, people lay too little emphasis on the art of social intercourse and indeed to their disadvantage, but just because it is an art it must be frequently practiced and this practice is only possible in company. It can never be acquired within four walls.... It is well to be able to move in the most varied circles with great ease or to make yourself at home in any surroundings. I have schooled myself in this art all my life and have much still to learn.

The secret of his social success, whether in palace or in tavern, was that he was always himself. Any affectation was foreign to his nature.

> He who, in the strict sense, lives only for science, is an idolater; how often do I thus err and how many others are guilty without recognizing the horror and culpability of this sin.

Though not a church man, Schönbein was deeply religious and his scientific views were sometimes influenced by his religious convictions. For atomism he had little sympathy, because he felt that there was too close a bond between this theory and materialism. The universe to him was the ordered creation of an omniscient God and consequently he believed that nature should be approached with respect and modesty.

> No matter how great the sum total of human knowledge may appear, the most experienced investigator knows well how fragmentary and imperfect is our information; and he is convinced that only an infinitely small fraction of the real nature of things may be known or studied.

The outstanding characteristic of Schönbein's work and writings was the independent course he followed, for he disregarded the three main currents of the stream of chemical thought of his time, viz.: quantitative measurements, organic formalism, and the atomic viewpoint. This iso-

lated position doubtless contributed to the tardy recognition of the worth and correctness of many of his findings and predictions. He and some of his friends thoroughly enjoyed his heterodoxy. St. Claire Deville wrote him: "My dear master of chemical sorcery: Had you lived two hundred years ago, you would justly have been burned for your chemical eccentricities." And yet the really great chemists of his time knew his true worth. Graham wrote: "The standpoint from which you have always surveyed chemistry is high and philosophical." Schönbein's creative imagination led him to the alteration of old views and to the formulation of new hypotheses, which often were found erroneous.

As for me, the determination of the truth is far more important than the maintenance of my views, for why should one hold fast to notions that will not withstand the criticism of facts. The sooner they fall, the better, even though *prima facie* they appear ever so ingenious.

In an era in which quantitative methods were *comme il faut*, he relied almost entirely on qualitative reactions, and yet so keen was his insight, so excellent his observational powers, and so resourceful his talents for devising conclusive experiments that his results are classic examples of important results derived from modest material resources. Hagenbach wrote: "His apparatus was exceedingly simple; a few test glasses, flasks, retorts, and bottles, an alcohol or a gas burner usually sufficed for his chemical studies.—'Not how much,' but 'how?' was his chief interest." G. Lewis recently wrote: "I have no patience with attempts to identify science with measurements, which is but one of its tools, or with any definition of scientist which would exclude a Darwin, a Pasteur, a Kekulé" (or, may we add, a Schönbein). This narrow, quantitative method, this "intellectual snobbishness," or "scientific chauvinism" was not employed by him when seeking the reasons for the manifold changes suffered by materials subjected to the action of external influences. The dynamic aspect of chemical reactions was always of great interest to him. To Liebig, he wrote:

Every chemical process of synthesis and of analysis consists of a drama composed of different acts, a true *processus*, *i. e.*, a beginning, a middle, and an ending. Present-day chemistry takes practically no account of such relationships, in spite of their theoretical significance.

Likewise to Faraday:

Shakespeare says that there are many things between heaven and earth which the philosophers do not even dream of and Schönbein maintains that between the moment in which two isolated elementary bodies meet and that of their chemical association being finished, there lies a whole world of phenomena, and is very much of which chemists of the present day have not as yet the slightest notion.

To one holding such views, there was little charm in exact quantitative analyses of natural products or in the preparation of new compounds.

I have an almost unconquerable shyness for the organic field of chemistry. (This feeling never left him.) The preparation of thousands of organic compounds seems to me but little more than the infinite number of designs obtained with a kaleidoscope. The thousands of these images which the activities of chemists have brought into the light of day, have contributed little to a better understanding of chemical action and throw practically no light on the main questions.

Faraday, Grove, Graham, and even Liebig and Wöhler, agreed with him in whole or in part, for they felt the limitations and dangers of formalistic organic chemistry which then seemed to threaten the exclusion of all the rest of chemistry from the field of serious study. As Kahlbaum wrote, "The command 'Thou shalt not make for thyself any graven images' was written for organic chemists also."

Schönbein also could see little merit in the atomic theory.

It appears to me that nowadays there is too much talk among chemists of particles, molecules, nuclei, etc., with a view to explaining phenomena which possibly, or even probably, may rest on something quite distinct from the mechanical arrangement of hypothetical atoms. Nothing is easier than manipulation of minute particles, for whoever has a bit of geometrical imagination can build whole worlds from a suitable supply of atoms, just as easily as a cook can make his plum puddings from flour and raisins.

After listening to a conversation between Liebig and Wöhler, anent the atomic theory, he burst out:

Go along with your atoms; why are there not atoms as big as liver dumplings so that people could know more about them?

Schönbein's teaching was restricted almost entirely to his lectures. His laboratory methods were so simple and the conclusions drawn from them so dependent on the observational skill of the experimenter that he felt no urge to encourage students to work in his laboratory. Indeed he was thankful when their absence gave him more time for his writing. His lectures were clear, free of unnecessary speculation, and his delivery held the attention of the audience. He was much in demand for popular scientific addresses. The following excerpt from notes taken at one of his lectures on oxygen reveal the modesty with which he mentions his now most important discovery, ozone:

It was left for Lavoisier to endow the discovery of oxygen with its entire significance when he founded a new theory of oxidation and combustion on which nearly all of the newer chemistry rests. This element has received an additional significance through the discovery of its allotropic modification, which likewise threatens to revolutionize the existing chemistry.

More than 350 publications issued from his pen. These are mostly short papers and only occasionally could he be persuaded to compile longer essays in which were brought together the essential points of the briefer articles.

His career as an investigator extended over the period 1836 to 1868 and it constitutes a unique example of devotion to a single element, oxygen, whose reaction and modifications run like a *leit motif* through all his work. Is it strange that he grew to love this material and to be jealous of its supremacy among the elements? The rôle played by hydrogen in acids was accepted, but the oxidizing powers of the halogens seemed too much to bear, so Schönbein reverted to the assumption that these elements were oxides of the hypothetical elements, murium, etc. He wrote to Faraday,

> Upon many agents, considered as equal to oxygen, he (Schönbein) looks down as upon upstarts and usurpers, assuming powers and privileges to which they have no right and declares that an infinite number of glorious deeds ascribed to the agency of inferior deities are in fact the work of what he calls "Jove of the philosophical Olympus."

The reluctance with which Schönbein accepted the newer views and trends in chemistry and the rather restricted range of his researches, might lead some to conclude that he was constantly looking backward. In truth he was fully conscious of the need for new methods and broader outlooks. He foresaw the necessity of developing what has now become physical chemistry.

> Physics must be used in furthering the understanding of chemical phenomena to an extent greater than ever before. This is only possible if we can find relief from the condition that the physicists, as a rule, are too little chemists and the chemists too little physicists to be able to take an active interest in the topics treated by the other science. The prevalence of this evil makes itself most evident when chemistry and physics, so to say, coincide, as in the study of electrolysis. Here the mere physicist can accomplish just as little as can the mere chemist. In the interest of science, it is greatly to be desired that the examples of Berzelius, Gay-Lussac, Daniell, Grove and Faraday be more commonly followed, and that physics and chemistry be more closely united than heretofore.

The younger and the less eminent of his contemporaries were often prone to regard Schönbein with silent contempt, but the really great of his time recognized his worth as an investigator and thinker. He was elected to membership in many of the outstanding scientific societies. His achievements cannot be summed up in a few lines and he little deserved the partial oblivion into which his memory had fallen until Kahlbaum so ably brought his work and character to the attention of a world to whom Schönbein had become a hazy figure.

Volhard wrote, "Schönbein was small in stature, very fat, mobile as a ball, and full of bubbling humor; as a chemist, about like the popular notion of an alchemist." His health was uniformly excellent, but in his later years he suffered much from gout and arthritis. Liebig prescribed lithium carbonate for his ailments and kept his friend supplied with this remedy. Schönbein died quite unexpectedly in Baden on August 29, 1868,

and was buried at Basel. At the end he was repeating the Lord's Prayer and his last words were "forgive our debtors." Liebig wrote to the widow: "In this great sorrow no one dares to speak of solace, but we must express our deepest sympathy. You have lost an affectionate husband, your children a loving father; your loss is infinitely greater than ours; he was such a good man, beloved by all who really knew him, a devoted loyal friend."

A VARIANT METHOD FOR SOLVING CHEMICAL PROBLEMS

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In the solution of chemical problems involving weights only, it may be of interest to compare the usual method with another in which the number of mols of the reacting substances is made the basis of the computation. Illustrative problems may, perhaps, make the matter clearer.

Problem. How may grams of nitric acid are required to react with 12 grams of copper in the preparation of nitric oxide? (Cu = 64.) Usual method.

(1) $3Cu + 8HNO_3 \longrightarrow 3Cu(NO_3)_2 + 4H_2O + 2NO$

(2) $3 \times 64 \quad 8 \times 63 \quad 3 \times 188 \quad 4 \times 18 \quad 2 \times 30$

(3) $12 \quad x$

(4) $\frac{192}{12} = \frac{504}{x}$ (5) $x = \frac{504 \times 12}{192}$ or 31.5 grams.

Proposed Method

It is clear that for every 3 mols of copper 8 mols of acid are used; the number of mols of acid is therefore 8/3 the number of mols of copper. We have 12 grams of copper but 64 is the weight of one mol of copper; therefore we have 12/64 of a mol of copper. The number of mols of acid is therefore $12/64 \times 8/3$ or 1/2 mol. One mol of nitric acid is 63 grams so the weight of acid is $63 \times 1/2$ or 31.5 grams.

Problem. How many grams of sulfuric acid are required to react with 12 grams of copper in the preparation of sulfur dioxide? By the usual method of computation we have for step four, as shown above, $\frac{64}{12} = \frac{196}{x}$ whence x equals 36.7 grams. By the proposed method the reasoning is: it requires 2 mols of acid for each mol of copper and we have 12/64 mols of copper. Hence, the number of mols of acid is $12/64 \times 2$ or 3/8 mol of acid. One mol of acid is 98 grams, hence we have $3/8 \times 98$ grams or 36.7 grams.

The advantages of this method are offset by the fact that it is not given in our high-school texts. The simplicity of the method is obvious and ease of solution is evident since generally we have to deal only with relatively small numbers.

LIQUID AMMONIA AS A SOLVENT AND THE AMMONIA SYSTEM OF COMPOUNDS. IV. EXPERIMENTAL PROCEDURES INVOLVED IN THE MANIPULATION OF LIQUID AMMONIA SOLUTIONS[1]

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Although liquid ammonia has been rather widely used as a solvent medium, one must not gather that the investigation of ammonia solutions is without experimental difficulties. Such is far from being the case. Ammonia, it will be remembered, is a gas under ordinary conditions. It can be readily condensed, however, to a clear liquid boiling at $-33.4°$ under one atmosphere pressure. Since this liquid has a vapor pressure approaching 8.5 atmospheres at the ordinary temperature, $+20°$, reactions in liquid ammonia at this temperature must be carried out in tubes constructed to withstand high pressures. For studies of solutions at atmospheric pressure, the containers must be cooled to the boiling point of the solvent. Because ammonia readily absorbs moisture, it is further necessary to design apparatus that eliminates this source of contamination. Indeed, the development of a technic for the convenient manipulation of liquefied gases is one of the outstanding and more important accomplishments resulting from the study of liquid ammonia solutions.

Any treatment of manipulation involved in working with liquid ammonia divides itself logically into three headings; (1) obtaining the liquid from the supply tank and purifying the commercial ammonia, (2) reactions at low temperatures, and (3) reactions under pressure.

Liquid Ammonia from the Supply Tank

Very pure ammonia may be readily obtained today at an unusually low cost. Most of the liquid on the market is a synthetic product made directly from its constituent elements. It is very nearly anhydrous and free from appreciable amounts of volatile and condensable impurities.

Figure 1 represents the method used for getting the liquid directly from the large tanks sold by the manufacturers. The tank is inclined slightly from a horizontal position by placing it on a substantial wooden stand. (Tanks of different capacities may be purchased but the usual commercial sizes contain 50, 100, or 150 pounds of ammonia.) The pressure of the vapor A above the liquid is several atmospheres, depending upon the temperature of the surroundings. The outlet B is so constructed that its origin dips into the liquid at the bottom of the tank, providing the tank is

[1] Previous papers in this series have appeared as follows: I, THIS JOURNAL, **5**, 664–70 (June, 1928); II, *Ibid.*, 828–35 (July, 1928); III, *Ibid.*, **6**, 20–35 (Jan., 1929).

placed in the position represented in the sketch. When valve C is opened,[2] the pressure of the vapor in the space above the liquid forces the ammonia out through B. A vacuum-jacketed receiver E is supported by being clamped on a ring stand and the rubber or lead tube D connects the tank outlet with the receiver. The tube G is an outlet for the ammonia vapor which may most conveniently be kept out of the atmosphere by bubbling into a bottle of water. The mercury trap H prevents water being sucked back into the receiver when ammonia is not being run from the tank.

The procedure for obtaining the liquid is comparatively simple. With stopcock F closed and G open, the valve C is opened slowly. At first only vapor passes through the system but the evaporation soon cools the ammonia to its boiling point at atmospheric pressure, 50° below room temperature. This liquid then cools the materials with which it is in contact and liquid ammonia runs over into the receiver. When the desired quan-

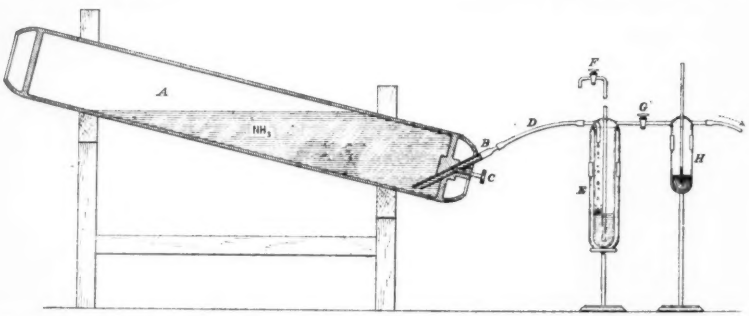

FIGURE 1.—APPARATUS FOR WITHDRAWING LIQUID AMMONIA FROM THE SUPPLY TANK

tity of the liquid has been withdrawn from the tank, valve C is closed and a Dewar vessel placed under the outlet of the container. On opening stopcock F and closing G, the pressure of the gas above the liquid forces ammonia over into the Dewar tube. The liquid may be withdrawn directly into the Dewar containing flask without the intermediate receiver but this method is on the whole less satisfactory than the one described.

The Dewar vessels employed in ammonia work are seldom silvered. The clear glass enables one to see the changes taking place during the course of a reaction. Such a flask when well evacuated will retain ammonia for several hours. It has been found advisable to construct these flasks of

[2] Since the valve on a commercial ammonia cylinder is oftentimes difficult to regulate and since a wrench is required for turning the valve, it is convenient to attach an ordinary globe valve to the outlet on the cylinder. The valve on the container may then be opened permanently, the supply of liquid ammonia being regulated by the globe valve.

Pyrex glass since it is less sensitive to mechanical shock and rapid temperature changes than most varieties of soft glass. The ammonia obtained in the above manner is used for cooling reaction vessels to the boiling point of the solvent or even for carrying out certain reactions where the presence of small amounts of water in the ammonia is not objectionable. However, such ammonia is not satisfactory for most purposes since by far the larger proportion of reactions that are carried out in this solvent require the removal of all water. It is also highly desirable to have ammonia under a slight pressure so that it may be distilled from one part of an apparatus to another. These two factors may be cared for experimentally by filling small storage tanks with liquid ammonia. These tanks may be of the type shown in Figure 2.

Such a storage cylinder must withstand a pressure of several atmospheres and is made of heavy steel tubing with welded ends. Through the top piece a steel block is threaded which contains a needle valve at each end, C_1 and C_2. The valve C_1 allows passage through the long tube to the bottom of the cylinder while valve C_2 provides an opening to the top of the cylinder.

FIGURE 2.—STORAGE CYLINDER FOR ANHYDROUS LIQUID AMMONIA

The process of filling the cylinder with liquid ammonia is similar to that used for filling Dewar flasks. After the tank has been tested for leaks, a few grams of metallic sodium are dropped into the cylinder and the block at the top containing the valves is screwed into position. A small steel or lead tube connects the cylinder at T with the large supply tank (Figure 1) at B. Both valves, C_1 and C_2, are opened wide while C is opened slightly to allow ammonia gas to pass through the entire system, thereby displacing all of the air. In order to maintain a difference in temperature the cylinder is cooled by being partly immersed in a pail containing ice and water. Then valve C_2 is closed, C_1 opened wide, and finally C (Figure 1) is opened. The liquid ammonia quickly passes through the small tube and the opening T to the bottom of the cylinder. If any air, hydrogen, or other non-condensable gases remain in the tube to slow up the flow of the liquid, valve C_2 may be opened to allow these gases to escape. When the cylinders are two-thirds filled with liquid, all valves are closed and the connecting steel tubing removed.

Another type of tank frequently employed to store small amounts of ammonia is shown in Figure 5. These cylinders differ in no essential from the steel flasks frequently employed for transporting metallic mercury. They are fitted with needle valves and hold from three to five pounds of liquid ammonia. The removal of non-condensable gases from these tanks

is accomplished by first running a small amount of the liquid into the tank, then disconnecting it for a time from the supply tank and, by opening the needle valve slightly, permitting any foreign gases to escape into the atmosphere because of the pressure of the evaporating ammonia.

Precautions must be taken not to fill the tank more than two-thirds full. The coefficient of expansion of the liquid is high and the pressure within a full tank when the temperature of its contents has risen to that of the room may be great enough to split the walls. The filling may be easily controlled by placing the cylinder and surrounding cooling bath on a large platform scale. The capacity of the cylinder must, of course, be determined beforehand and then, from the capacity, the weight of ammonia to be added.

The metallic sodium, added to the tanks to remove water, is highly soluble in liquid ammonia and distributes itself throughout the liquid. This sodium reacts immediately with any water that may be present to form highly insoluble sodium hydroxide and liberates hydrogen gas. The methods used for removing the hydrogen have already been mentioned. Usually more sodium than is required to remove the water is placed in the cylinder but this excess amount rapidly reacts with the ammonia, forming very slightly soluble sodium amide and hydrogen gas, the iron of the cylinder acting as a catalyst for the reaction.[3] A storage cylinder containing sodium will furnish pure dry ammonia suitable for all operations involving the liquid. The outlet of the cylinder may be attached to a glass line through which the gas can be readily passed to any desired apparatus.

Reactions at Liquid Ammonia Temperatures[4]

In carrying out many reactions in ammonia at its normal boiling temperature, —33.4°, a reaction tube of the type shown in Figure 3 is highly satisfactory. In order to maintain the temperature of the vessel at the boiling point of ammonia, it is placed in a Dewar tube to the level *H* and attached to the latter by a rubber stopper fitting. A piece of glass tubing fitted through a small hole in the stopper allows the ammonia gas from the Dewar flask bath to escape into a waste line which runs into a container of water.

In order to condense ammonia at its boiling point, the gas must be supplied at a pressure of several centimeters above that of the atmosphere. This is accomplished by allowing the ammonia to enter the reaction vessel

[3] See THIS JOURNAL, **6**, 22 (Jan., 1929).

[4] For a more complete discussion see **Kraus**, *J. Am. Chem. Soc.*, **29**, 1557 (1907); **30**, 653, 1197, 1323 (1908); **36**, 864 (1914); **43**, 749 (1921); Krause and Lucasse, *Ibid.*, **43**, 2529 (1921); **44**, 1941, 1949 (1922); Kraus and Chiu, *Ibid.*, **44**, 1999 (1922); Kraus and Zeitfuchs, *Ibid.*, **44**, 2714 (1922); Kraus and Lucasse, *Ibid.*, **45**, 2551 (1923); Kraus and Johnson, *Ibid.*, **47**, 725 (1925); Kraus, Carney, and Johnson, *Ibid.*, **49**, 2206 (1927).

against a column of mercury of about 20 centimeters, since the other side of the mercury column is open to the atmosphere. Such a scheme is shown in Figure 3. The mercury column at *I* may be increased or decreased by raising or lowering a leveling bulb containing mercury which is connected to *K* by means of pressure tubing.

The following example illustrates the method used in studying a reaction. Suppose we wish to determine the stoichiometric relations involved in the reaction of ammonium bromide with metallic sodium dissolved in liquid ammonia. The reaction that takes place is:

$$NH_4Br + Na = NaBr + NH_3 + 1/2H_2$$[5]

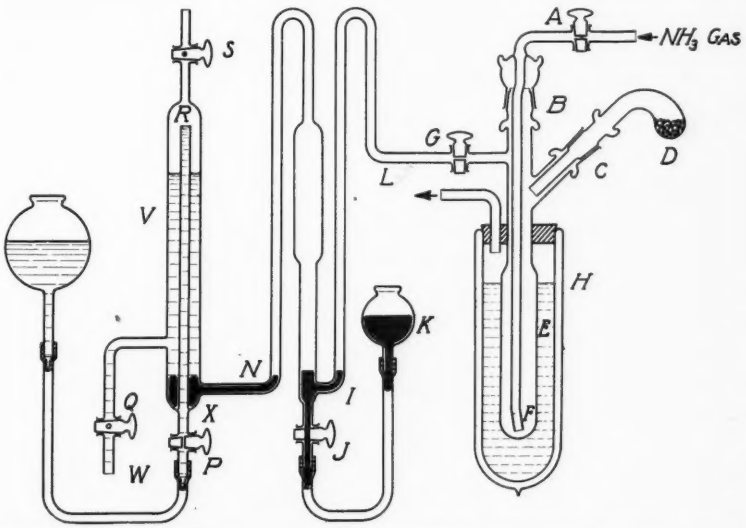

FIGURE 3.—APPARATUS FOR CONDUCTING REACTIONS IN LIQUID AMMONIA AT ITS NORMAL BOILING POINT

Ammonia gas is first allowed to pass through the tube at stopcock *A* to the bottom of the reaction vessel through tube *F* until all the air has been displaced in the system. With a small stream of gas still flowing and the cap on the side tube removed at *C* (glass ground joint), a freshly cut piece of sodium (difficult to weigh) is introduced through the opening and falls to the bottom of the reaction vessel *E*. The side tube is put back into position and securely fastened by means of rubber bands which are strung be-

[5] Ammonium bromide is an acid in liquid ammonia, therefore the strongly electropositive element sodium reacts readily to displace the hydrogen of the acid to form the salt, sodium bromide. This reaction is strictly analogous to that of zinc and hydrochloric acid in water. Cf. THIS JOURNAL, **5**, 668 (June, 1928).

tween the corresponding ears shown in the figure. The mercury bulb K is then raised, with stopcock J open, to increase the height of the column. The reaction tube is then set into a Dewar tube in the manner previously described. The pressure of the ammonia gas coming from the storage cylinder is increased sufficiently by this procedure to condense the vapor in E. The tube F soon becomes surrounded with liquid and the ammonia gas bubbles through at the extreme end to keep the liquid ammonia solution of sodium well agitated. When several cubic centimeters of the liquid are present in E, the mercury column I is again lowered to prevent further condensation of the ammonia vapor and the pressure of the gas at the tank is decreased so that only a slow stream stirs the solution at F. The side tube containing dry ammonium bromide at D, having been previously weighed, is now turned about the glass ground connection C as an axis through an angle of about 120° so that by gentle tapping small pieces of the ammonium bromide are introduced into the solution below. The solution is well stirred and ammonium bromide is added slowly until the blue color of the dissolved sodium has been completely discharged.

The dissolved sodium serves as a good indicator for the reaction since only a small part of a milligram in solution is sufficient to produce a blue color. As soon as the color has disappeared, the tube may be reweighed and the amount of ammonium bromide used determined by difference. From this value may be calculated the amount of sodium that took place in the reaction.

According to the above equation, every mole of ammonium bromide liberates one-half mole of hydrogen gas. Figure 3 shows how this gas may be collected and the volume determined. The tube V is filled with air-free water and contains a small amount of mercury at the bottom which serves as a trap. The tubes P and W connect to bulbs containing water open to the atmosphere. At X the small tube R is sealed inside the larger tube V. This construction gives a means for introducing water during the course of the reaction through P and thus through R and at the same time for withdrawing ammonia solution at W. In this way the water that is saturated with ammonia may be replaced by fresh water.

The hydrogen gas liberated in the reaction tube is carried out of the tube by a fairly rapid stream of ammonia gas through L, through the mercury at I, and over to the collecting tube V. The hydrogen displaces the water and the ammonia is absorbed. If tube V is calibrated, an estimate of the amount of hydrogen liberated may be made providing the partial pressure of the water and ammonia vapors are taken into consideration. An accurate determination may be made by opening stopcock S and allowing the mixture of gases to pass over phosphorus pentoxide to remove both water and ammonia. Then, by means of a Töpler pump, the hydrogen may be pumped into a container of known volume, its pressure measured

and finally the total corrected volume calculated. This value may be checked by exploding a definite volume of the gas with air or oxygen. The amount of hydrogen will correspond to the weight of ammonium bromide used in the reaction.

Reactions under Pressure

The methods used in working with liquid ammonia under pressure have been described in considerable detail elsewhere[6] and a reiteration of them would require much more space than is available here. At best one can hope only to give a general idea of the manipulations involved. Such reactions are ordinarily carried out in Faraday tubes, or ammonia tubes as they are frequently called, which are ∧-shaped tubes with a stopcock at the upper end (Figure 4). As a supply of ammonia, one of the small storage

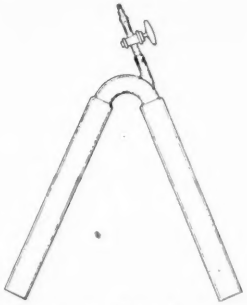

FIGURE 4.—THE AMMONIA TUBE

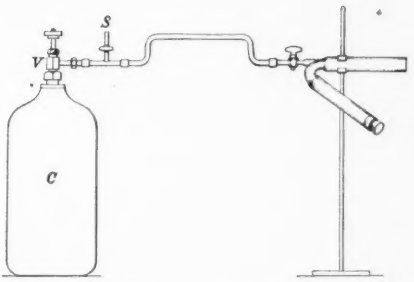

FIGURE 5.—FILLING THE AMMONIA TUBE

tanks fitted with a piece of flexible lead tubing is used. When it is desired to fill a reaction tube, the latter is clamped in a horizontal position and the stopcock of the tube fastened to the end of the lead tubing (Figure 5) with sealing wax. Thus it is possible to have a slow stream of gaseous ammonia run through the tube and thereby displace all the air. Warming the legs of the tube by means of a hand torch vaporizes any water condensed on the glass. The ammonia stream carries away this moisture. (While warming one leg, the other is closed with a cork stopper.) The substances to undergo reaction are placed one in one leg of the tube and the other in the second leg. Following this operation the ends of the tube are sealed off, care being taken to prevent any moisture from the flame entering the tube. To do this a glass rod is fused on to the end of the tube for a handle and, when the

[6] Franklin, *J. Am. Chem. Soc.*, **27,** 831 (1905); **29,** 1275 (1907); **35,** 1460 (1913); *J. Phys. Chem.*, **15,** 510 (1911); **16,** 693 (1912); Fitzgerald, *J. Am. Chem. Soc.*, **29,** 1694 (1907).

tube has been drawn down, as shown in Figure 6, the ammonia stream is retarded and the stopcock S at the cylinder is opened. The seal may now be completed; the pressure needed for rounding out the end of the tube is obtained by momentarily closing the outlet at S with the finger. Strains must be removed from the tube by careful annealing. This is accomplished by gently warming the leg for a distance of about two inches back from the end until the flame of the hand torch is just tinged with a yellow color.

FIGURE 6.—DRAWING DOWN THE ENDS

When the sealed ends have cooled, one leg of the tube is partially immersed in a battery jar containing ice and water (by bending the lead tubing) and ammonia distilled into the tube under pressure (Figure 7). This is accomplished by closing the stopcock S and opening the valve V. When the tube is charged with liquid, the supply of ammonia from the tank is shut off, the stopcock of the ammonia tube closed and the pressure existing within the lead tubing released by opening S. Then the reaction tube is disconnected from the lead tubing after softening the wax joint.

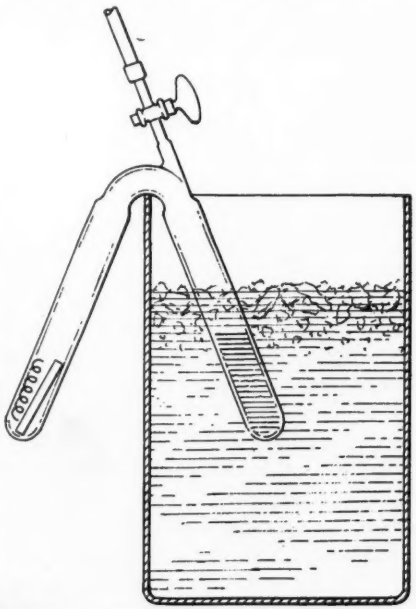

FIGURE 7.—DISTILLING AMMONIA INTO THE TUBE

By following the procedure outlined above it is possible to obtain anhydrous liquid ammonia solutions in containers which are easily handled and which permit the observer to watch the contents of the tube throughout the course of a reaction. There is considerable danger attendant upon the use of tubes containing liquid ammonia at room temperature because of the high pressure existing within the glass tube (eight atmospheres). Hence, it is customary to work behind glass screens to prevent injury to the observer in case a tube "blows up."

When ammonia is distilled into a tube in the manner described above,

the liquid condenses in but one leg of the tube. To obtain liquid in the other leg it is only necessary to immerse that leg in a battery jar of ice water and the other leg in luke warm water. The differential temperature causes ammonia to distil from one leg into the other.

After the substances within an ammonia tube have dissolved it is only necessary to pour the solution from one leg into that in the other to effect reaction. Thus a Faraday tube is essentially two test tubes fastened together. If the product of the reaction is a precipitate, it is allowed to settle to the bottom of the leg of the tube. On inclining the tube, the supernatant liquid can be decanted into the opposite leg. To wash the precipitate, pure ammonia is condensed in the leg containing the precipitate and then, after shaking the tube to stir the precipitate and allowing it to settle again, the supernatant liquid is poured off as before. Thus, by a reasonable number of washings, any soluble impurities can be removed from the precipitate. If the product of the reaction is soluble, crystals can often be obtained by cooling the tube in liquid ammonia contained in a Dewar test tube or in a mixture of carbon dioxide snow and ether. By careful manipulation the crystals can be washed in the same manner as a precipitate. When one of the reaction products is a gas, the stopcock of the tube is opened slightly and the gas collected over water, the ammonia escaping and at the same time dissolving in the water. Figure 8 shows an arrangement for collecting a gas. In using such a device it is essential that the liquid in both legs of the ammonia tube boil so that all gases will be swept out of the tube. For analysis the gases are withdrawn from the collection tube through stopcock B into a suitable apparatus.[7] When the washing of a solid product, precipitate or crystals, is completed, the leg containing the washings is sealed off and the pure product, ready for analysis, remains in the other leg. Prior to this manipulation, the ammonia within the tube is either permitted to escape or is distilled into the waste leg of the tube and cooled to —33.4° by immersing that leg in a bath of liquid ammonia.

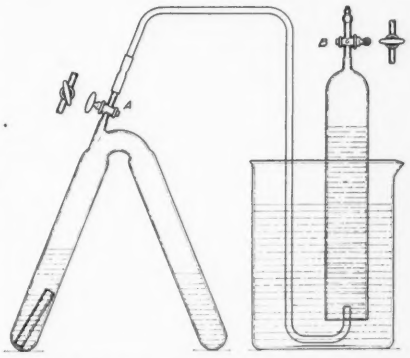

FIGURE 8.—COLLECTING GASES EVOLVED IN A REACTION

For analysis the one-legged tube containing the sample is attached to a

[7] This method of collecting gases was devised by Dr. F. W. Bergstrom and is described (in part) by him in the *J. Am. Chem. Soc.*, **47**, 2320 (1925).

Töpler, mercury vapor, or mechanical pump, evacuated and then weighed. To wash the sample from the tube, the device shown in Figure 9 is used. The tip of the evacuated tube is dipped into a crucible or small beaker of the solvent and the stopcock turned to admit a small amount of the liquid (usually a dilute aqueous solution of an acid). By attaching the tube to *A*, as shown, and a water pump to *B*, the solution is drawn into the small Erlenmeyer or volumetric flask and the tube evacuated sufficiently to enable it to draw up another portion of the solvent. This operation is repeated as often as desired and the tube rinsed out with alcohol before the final evacuation. The solution of the sample is then made up to 100 cc. or 250 cc. from which aliquots are withdrawn for analysis. The weight of the empty, evacuated tube permits one to calculate the weight of the sample by difference.

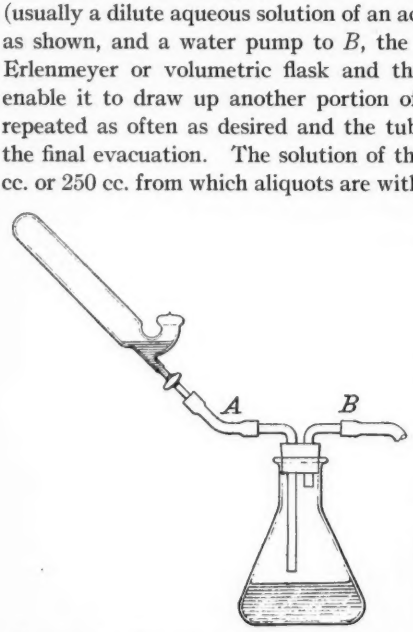

FIGURE 9.—OBTAINING THE SAMPLE FOR ANALYSIS

Considering the small size of an ammonia tube as well as the high pressure existing within it, it seems remarkable that so many operations can be carried out in such an almost completely isolated container. In truth, however, the very isolation of such a system is an advantage because there is no danger of contamination from the surroundings. The variety of conditions under which these tubes are useful, though, is worthy of mention; for example, the contents of one and the same tube may with equal ease be examined at the frigid temperature of boiling ammonia (—33.4°) or of a mixture of carbon dioxide snow and ether (about —78°) or at moderate heat (about 50°), in all a range in temperature of over 125 degrees. Recently a means has been perfected for heating ammonia solutions up to 300°.[8]

Sufficient has been said to convey a general idea of the nature of the manipulations involved in handling liquid ammonia and its solutions. In all, this technic is relatively simple and requires no particular skill other than a slight knowledge of glass blowing. The development of a means for studying reactions in liquefied gases, however, is truly an achievement of note. The future will doubtless see a widespread use of such manipulations.

[8] Blair, *J. Am. Chem. Soc.*, **48**, 91 (1926).

THE PROBLEM OF POLISH ACADEMIC SCHOOLS AS DEMOCRATIC CENTERS OF EDUCATION[1]

W. SWIETOSLAWSKI, POLITECHNIKA, WARSAW, POLAND

The higher academic schools are called upon at present to undertake two duties which are vital to the existence of the State as a whole. They ought to be centers of education and preparation for practical activity to a corps of many thousands of students and they ought also to be centers for the development of science, making careful researches and improving technical science in the broadest meaning of these terms. The separation of these related duties and activities of the higher school, the narrowing of the problems and aims of the academic school to the rôle of a teaching establishment with the transfer of scientific research to the special inquiry institute was not resolved upon till the present time in any country, and probably will not be in this way decided. Teaching cannot be separated from constant contemporary scientific research. Were these two spheres artificially severed, a slow death would await the academic school.

If rich countries can afford to found great and numerous research institutes, poor countries must exert all their energies toward the material support of academic schools as centers of development of pure and applied science. The poorer the financial resources of any country, the weaker is the development of industry, the fewer are the citizens who possess accumulated material resources, and the more difficult is the creation of well-ordered institutes for special research. In just such a condition is Poland. She possesses neither a State machine rich in means nor a duly developed industry, and great wealth is not accumulated in the hands of her individual citizens. Therefore, the development of science in Poland must be joined in the most direct way with the general development of academic schools. This conjunction would concentrate the forces on which must be based all progressive movements: science, culture, creative research, and, in a great degree, invention.

On just this ground must we examine the actual position of academic schools, and on this base our discussion of means to develop these schools into centers of scientific research. We will first consider briefly the obligation which rests upon the higher schools to coördinate this development as centers of instruction for the masses of young people. Let us freely confess that neither the government nor the higher schools, as such, have as yet elaborated a systematic plan of supplying the State as a whole with professional forces. They are imbued with the old conviction that life itself is the best regulator and that the law of supply and demand will govern automatically the flow of professional forces. This generation

[1] Discussion at the Second Meeting of Polish Scientists in 1927. Translated from the periodical "*Nauka Polska*" (*Polish Science*), **7** (1927), Warsaw, Poland.

must condemn such a point of view because of its visibly harmful results. It is particularly dangerous in periods of great stress such as that which has followed the war, and may injure the cultural development and economic equipment of our reborn land.

Due to a lack of statistical material, what is taught in the higher schools at present or what is undertaken in the future may cast an unfavorable reflection on the general cultural and economic progress of the State. We have no accurate data on the number of intellectual workers who have academic education, their rate of mortality, or the average time required for their professional duties. Perhaps, for this reason, we so often hear even those in high authority declaring that the number of students in Poland's higher schools is excessively great and that the present state leads to hyperproduction of intellectual workers and to the further pauperization of intelligence.

Let us demand a systematic examination of the problem of the positive supply of professional forces and the basing on it of every undertaking in the plan of development of instruction in Poland's higher schools. In the absence of such statistics, we must for a time depend upon pre-war data, using the relation between the number of students and the entire population in four of the great cultural states of Europe. We have the following figures:

Country	Number of students per 1,000,000 inhabitants
Germany (1912)	1270
France (1912)	1210
Austria (1910)	1040
Switzerland (1912)	1247
Average	1192

As the average course of study before the war was from six to seven years, we deduce from this that the annual production of professional specialists amounted to 170 to 200 in every million inhabitants. If, similarly, the course of study of a Polish student covered a period of 6 to 7 years, the total number of students in Poland should equal 34,000. Unfortunately, however, the average course in Poland exceeds ten years, a fact which reduces the number of students in higher schools to a figure between 48,000 and 56,000 students and the annual output of graduates between 4800 and 5600. The actual number of students in higher schools in the academic year 1925–26 was but 32,156.[2] The number finishing therefore did not exceed 3000.

These calculations can be controlled by arranging a table of numeration for the various intellectual workers required throughout the State, but we possess no accurate statistics on this subject, and we can avail ourselves

[2] These figures were obtained through the Department of Higher Schools and Mr. Krautler, Manager of the Correspondence Department in the Chief of Statistics Office.

only of orientation data such as I gave in 1922[3] based on different sources. The following table shows the number of workers possessing higher education who are required by the State:

Government and city officials, clerks, and army officers	30,000
Technical forces employed in industry and mining	20,000
Teachers of high schools, colleges, and professional schools	20,000
Physicians, veterinarians, and pharmaceutists	15,000
Employed in commerce, banks, and technical offices	15,000
Non-specified professions	20,000
Total	120,000

When we consider that over 10,000 physicians are practicing in Czechoslovakia and that the number of teachers in the Polish gymnasiums alone exceeds 15,000 at the present time, those figures are not high. Considering further, since the average life-span of an official employee in our State scarcely exceeds 50 years and the intellectual worker fulfils his functions on an average in from 20 to 25 years, we set the yearly demand of professional forces in the Polish Republic between the limits of 4800 to 6000 persons. We observe that this number agrees with that formerly established, as based on the number of students and the duration of their studies abroad before the war. These figures are a minimum rather than a maximum requirement. Therefore, in speaking of the number of students in Germany and many other countries, we were not accounting for the numerous professional schools graduating young men with professional, almost academic, education, nor were we considering the fact that women form an important percentage of the students graduating from the higher school and that rather a large number of these do not capitalize their education.

These data point convincingly to the fact that the problem of academic schools as centers of preparation for young people for their future professional work is a great problem and that at present, in spite of the over-crowding of the high school, there is no basis for the complaint that the number of students is excessive. Finally, under present conditions, our schools cannot supply the State with the number of specialists that is really necessary.

The entire state of school affairs is endangered by present conditions. We all realize that an important function of the schools is to cultivate science in the broadest sense of the word and to foster careful scientific researches. It was for this purpose that the present congress of Polish savants was called—that it might find a satisfactory solution to this most difficult problem. I shall mention only those questions which are directly associated with the first of our problems cited, namely, projects leading to the improvement of the method of education of our young people in academic schools.

[3] "*Przeglad Techniczny*" (*Technical Review*), **16** (1921).

The fact remains that the academic schools, attended by approximately 33,000 students, are not able to graduate the number of professionally qualified specialists demanded annually and moreover they are excessively overcrowded. Financial difficulty is a constant obstacle in the way of building a greater number of higher schools, and the extreme poverty of three-fourths of our students is creating such hardships that an appreciable percentage of them do not complete their studies. A ten-year average course of study is too long.

In spite of the lack of accurate statistics, we are forced to the conclusion that the annual output of graduates does not exceed 3000. Society in Poland has accustomed itself to the undue length of university studies. Very few people complain of the fatal results of such a dissipation of the best years of our young people's lives. Our average student loses for his education from one-third to one-fourth of the time in which he should be performing normal functions connected with his profession. He enters into life tired, with weakened nerves, accustomed to treat his studies as an extracurricular occupation after business hours. Due to this, his energy and aptitude for creative work are deadened, and this factor we must of necessity keep in sight when we judge losses to the State and society in the face of such conditions. In a State as poor as ours and so much in need of the development of creative forces and the attainment of maximal efficiency of labor, this deplorable condition results in the dissipation of capital, which can only be judged as the most futile extravagance.

The radical cure of this evil rests with all factors concerned: the government, the higher schools, society as a whole, working toward a compact curriculum which will shorten the duration of school life.

The problem could be solved if we could assure to three-fourths of our students—22,000—the normal sources of livelihood. This would be possible if we could guarantee them the completion of their studies in a 4-, 5-, or at most a 6-year period. Help amounting to 1200 Zloty for a student would be satisfactory. Let the State and society arrange for our youths a long-system credit amounting to 26,000,000 Zloty. Strangely enough, the State and loan societies have no trouble supplying credit to industry and agriculture, assigning far greater sums than this, but, where students are concerned, they consider such credit as out of the question.

The creation of credit-institutions giving long-term loans to students, exclusive of philanthropy, will be the essential feature of such a program to protect the student and will be a fundamental problem, incidentally, for the government and the higher schools. Such a movement was initiated by the Department of Sciences in granting returnable scholarships, but its success will depend on the ability of private organizations to collect the loans granted and to maintain activity on a larger scale.

A more numerous personnel, professors, assistants, and other helpers for

teaching work would be a material factor in reducing the period of school life. The spreading demand for popular education has resulted in a tremendous overburdening of the teaching staff, not only in Poland, but in many other countries. At present, many professors are losing from 300 to 400 or more hours yearly in the control of teaching, such as the supervision of examinations and tests. When we remember that a clerk in a private or government office works 1800 hours a year, we see that a professor loses one-sixth or more of that time in examinations. Such overburdening of the teaching staff has a disastrous effect on the efficiency of teaching and consequently prolongs the period of school life. Added to this factor are the crowded condition of apartments, the lack of space in laboratories, and the long files of waiting students, which bring about temporary interruptions of study. Thus the slender material resources of our higher educational institutions combined with the students' financial distress tend to handicap our young people with a long-drawn-out course.

Systematic development of existing schools, followed by the establishment of new academic schools, is the only way to improve the situation. A greater number of professors' chairs must be created, and the professors must be granted the necessary number of assistants. The construction of new buildings and laboratories is a sure means of adjusting this situation.

A third important factor in the shortening of the course of study in the higher schools is the systematic control of studies. An accurate account must mention not only the numbers of students entering and graduating but also those compelled to interrupt their studies. A yearly collection of such data would give as a final result a general orientation and would characterize the academic schools as an outguard of education. Systematic research in this direction would lead, doubtless, to positive results. It would be very desirable to keep a real contact between the school and its graduates, so that after a definite lapse of time it would be possible to compare data as to their success in practical life. This information would have an important bearing on the development of a particular school as an educational center.

The problem of choice of the best means of preparing them for future scientific activity is the last question indirectly bound up with the education of young people. The present development of science and technical study forces us to speak not in units of tens, but of hundreds, who are called to scientific inquiry and research. The yearly effluence of professors and assistants must exceed one hundred, and even then the demand for scientific and creative work would not be met.

The question of the choice of personnel naturally must depend upon the individual professor or director, but the supply of workers and the assurance of work for them rests with the management of instruction and the development of science. What has been said concerning the loan funds for the youths in academic schools must again be emphasized here,

for intellectual workers must of necessity have sufficient means to guarantee them the possibility of carrying on research in an atmosphere untroubled by anxiety as to board and keep. Those who are preparing themselves for scientific research after finishing their studies are faced with the same problem. There can and must therefore be created the conditions necessary to normal supply of scientific forces in the State.

In conclusion, let us summarize as follows:

1. At present the number of students in academic schools in Poland is not excessive, while the number finishing higher schools is abnormally low.

2. Every means to reduce the average period of study to a minimum should be adopted.

3. The shortening of time for academic studies depends primarily upon material help for the students. We must found a special loan institution having an official, semi-official, or private character (free entirely of any mark of philanthropy) whose aim would be to grant long-term loans to the vast numbers of poor students.

4. The shortening of time devoted to studies also depends upon the further development and growth of higher schools. Increase in the force of professors with a corresponding impetus in the construction of buildings and the addition of laboratories and seminaries would doubtless contribute to saving the time of the students. The elaboration of a plan for creating new higher schools is the need of the moment.

5. It is desirable that the higher schools collect accurate data about the course of study of students and about the proportion of students who enter, who graduate, and those whose studies are interrupted.

6. It is desirable that higher schools publish from time to time data as to the success of their pupils and the degree of utilization of their professional training in later life.

7. We must develop statistics dealing with the masses preparing themselves for future scientific and pedagogical work, but the normal increase of individuals prepared for creative work depends above all upon the assurance of material existence for our young scientific workers.

Ether Takes Second Place as Surgical Anesthetic. Anesthetics given during operations have progressed greatly. Ether and chloroform are no longer the only agents the surgeon has to free the patient from pain. Some of the newer ones, particularly gas anesthetics, were discussed by Dr. Everett A. Tyler of Philadelphia at a medical meeting held recently in Washington. Gas and local anesthetics are now used very generally, with ether taking second place and chloroform out of the running, he said. The most important consideration in giving anesthetics is proper teamwork between the physician who examines the patient before operation, the surgeon, and the person who gives the anesthetic. The latter should be medically trained, said Dr. Tyler.—*Science Service*

SCHOOL AFFAIRS IN POLAND

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The problem of school affairs in the Polish Republic is a very great one and both the Polish Government and Polish society are highly interested in its development. Unfortunately, within the narrow limits of this article we may not fully consider this subject.

In the first place, let us realize that the Polish Republic during her 123 years of dependence (1795–1918) was divided into three annexed regions—Austrian, Prussian, and Russian. In all of these, the relations between the annexing government and the Polish population were different, according to the demands of the moment or the governmental politics. Therefore this problem must be considered separately for each region.

In the former Austrian Poland or Galicia, grammar schools and the middle schools (gymnasiums) were Polish, especially in the western district (Krakow). In the east of this part of southern Poland (districts of Lwow, Tarnopol, and Stanislawow) the above-mentioned schools were Polish for the Polish population and Ukrainian for the Ukrainian population. The schools were in rather good condition because of the Austrian government's political activity against Russia. It aimed to gain both populations for the cause of the Austrian Empire. There was the university founded by the former Polish Kings, Casimir the Great and Ladislas Jagiello (XIV century) in Krakow, and the one founded by John Casimir (XVI century) in Lwow. The Polish language was obligatory in both. During the period of the Austrian annexation there were founded a Polytechnic and a Veterinarian Institute in Lwow, and an Agricultural Academy in Dublany near Lwow. Here also Polish was the language of instruction.

In former Prussia (Upper Silesia, Poznan, and Pomerania) the Prussian government, from the time of her obtaining the leading influential rôle in the German Confederation and of the creation of the German Empire (1871), carried on anti-Polish politics and annihilated the Polish schools. The results of such a program were more than insignificant. The Plebiscite and the thrice-repeated insurrection in Upper Silesia (1919, 1920, and 1921), and the Poznan insurrection just after Armistice Day, are visible proofs.

In the central part of the former Russian annexation, in the so-called "Congress Kingdom," Russian gymnasiums and so-called "real schools" (mathematical-physics gymnasiums) existed with states' rights. In both types of schools the Polish language was taught for those students who wished to learn it. Warsaw University was founded on the site of Kadet-School where Thaddeus Kosciusko was studying (1765). It was opened in 1817 during the existence of the Congress Kingdom and had a checkered

career. The Polytechnic was founded in 1897. The teaching language of both was Russian; the professional staff was rather mediocre. Since the Russo-Japanese war (1904–05) and the revolution of 1905, the Polish Society proclaimed Russian schools as being under boycott. The Russian Government, weakened by the war, was obliged to consent to open gymnasiums where Polish was the teaching language. However, these schools were not given states' rights. A great number of teaching hours was reserved for the Russian language and in addition geography and history were taught in Russian. The Polish Society endured these schools although the fees were rather expensive in comparison with governmental Russian schools, and only the children of rather wealthy classes could attend them. After completing the course of study in such a private school the student was obliged either to go abroad for further study or to take a governmental competitive examination in Russian in order to be accepted by a university in Russia. It was easier for the Polish student in the schools of Central Russia to take such an examination. Grammar and professional schools were Russian and the Polish children were taught in Russian by Polish teachers.

In the eastern part of Poland (districts of Wilno, Nowogrodek, Polesie, and Wolyn) schools using other than the Russian language were declared illegal and abolished.

After Poland's recovery of her independence, a great task was incumbent on both the Polish Government and the Polish Society. It became evident that the formerly annexed German region had good buildings for grammar schools but a great lack of teachers, since the German teachers who did not know the Polish language at all had to be replaced by others. The same thing was done in the gymnasiums, which were entirely reorganized. The Poznan University was established four months after the Germans left Poznan. To supply the deficiency of professors and teachers in the former German territory, a new teaching staff was engaged from the former Austrian region and from the central part of Poland (Congress Kingdom). However, neither of these regions, especially the latter, had had sufficient numbers of professors and teachers.

During the German and Austrian occupation of the central part of Poland (1915–November, 1918), the Polish Society, planning to create an entire system of primary schools, opened teachers' training schools. This type of activity was a step toward remedying the evil found in the former German region and in the four eastern districts as well.

In the school year 1925–26 there were 27,389 active private and public primary schools with 69,046 teachers and 3,239,935 pupils. To prepare future members of the large teaching staff required, Poland had in the same school year 215 training schools for teachers with 37,292 students.

The following statistics show the steady yearly increase of teachers'

qualifications in public primary schools in absolute numbers and in proportions:[1]

Year	Total		Qualified		Temporary qualified		Unqualified	
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
1922–3	57,627	100.0	34,664	60.2	10,791	18.7	12,172	21.1
1923–4	61,447	100.0	38,352	62.4	11,303	18.4	11,792	19.2
1924–5	62,042	100.0	44,505	71.7	8,256	13.3	9,281	15.0
1925–6	64,658	100.0	49,900	77.2	6,664	10.3	8,094	12.5
1926–7	63,475	100.0	54,968	86.5	3,613	5.7	4,966	7.8

These data show that during a 5-year period there was a steady increase of qualifications for the teaching staff in public primary schools. While in the school year 1922–23, 39.8% of the teachers were temporarily qualified or unqualified, in the school year 1926–27 this proportion had been reduced to 13.5%. These figures show the vast amount of work accomplished in the matter of improving the qualifications of the teaching staff in the primary schools.

During the same period of time (1922–27) Poland had primary and government education:

Year	Schools	Teachers	Students
1922–23	27,384	62,003	3,208,352
1923–24	27,448	65,555	3,261,307
1924–25	27,414	66,176	3,237,340
1925–26	27,389	69,046	3,239,935
1926–27	26,565	68,343	3,346,335

The mother tongue of the pupils in private and public primary schools in the year 1925–26 was:

Polish	2,357,046
Ukrainian	398,062
White-Ruthenian	126,699
German	105,861
Jewish and Hebrew	227,283
Russian	11,266
Czech	3,049
Lithuanian	7,884
Miscellaneous	1,749
Unreported	1,036
TOTAL	3,239,935

The immense work done in the field of primary education shows the following statistical data. The number of children is counted on the basis of

[1] Statistics stated throughout this article have been taken from the Statistics Yearbook of the Polish Republic for 1927 and from the Statistics Information published by the Central Statistics Office.

the population of September, 1921, taking mortality into consideration. In Voievodship Silesia, 8 years of primary education were required (children from 6 to 13 years old); in the rest of the Polish Republic 7 years were required (children from 7 to 13 years old). The figures mentioned below include children enrolled in public and private primary schools, in schools of exercises for very young folk, and also those who attend gymnasiums but are less than 14 years old. The decrease in the year 1925–26 in comparison with the year 1921–22 is due to the decrease in birth-rate during the period of the European War. In the year 1921–22 children born in 1907–14 were attending school and therefore the influence of the war was almost nil.

PRIMARY SCHOOL SITUATED AT WISLA, VOIEVODSHIP DISTRICT, SILESIA

In 1925–26 the children who were in school were born from 1911–18, during three years of peace and four years of war.

Year	1921–22	1922–23	1923–24	1924–25	1925–26
Children of school age	5,075,166	4,870,763	4,537,548	4,248,112	3,941,900
Children in school	3,305,452	3,330,087	3,376,686	3,349,259	3,248,743
Percentage of children in school	65.1	68.4	74.4	78.8	85.0

All three annexing empires, Russia in particular, instituted the system of middle instruction (gymnasiums), which is entirely different and separate from primary schools. Such politics were maintained in order to separate the children of the rich or even the middle classes from the children of the people. With this aim in view, so-called preparatory or even pre-preparatory classes, in 8-class gymnasiums were added. But in Austrian and German annexed regions, existing conditions were such that the first four years of primary school became preparatory for the gymnasiums.

A long time before the European War, the Polish pedagogical thought conceived the following program as the ideal of the future: (1) general teaching for all children for 7 and, in certain cases, 8 years; and (2) middle schools (gymnasiums), accessible only to exceptionally gifted children, for an additional period of 4 or 5 years. This plan directly opposes the pre-war ideals established by the annexing empires, and approaches the ideal of teaching established by American, English, and, in certain aspects, French pedagogs.

The principle of this plan has met with general approval, but two existing conditions prevent its immediate acceptance: (1) the customs of the population and (2) the lack of buildings and partial lack of professors for the new model schools.

The greatest difficulty is the lack of buildings in the localities destroyed by the war, but each year witnesses progress. For the middle schools in Poland, statistics show that, notwithstanding the decrease in the numbers of pupils in 1925–26 as compared with the year 1922–23, there has been a steady increase in the examination certificates awarded. This decrease noted was due not only to the lowered birth-rate during the period of the European War, but largely to the attendance of children in the common schools for the lower grades. In many gymnasiums the former parallel classes of the first, second, and third grades (or lower gymnasium) have been combined, while parallel classes in the fourth, fifth, sixth, seventh, and eighth grades (or so-called higher gymnasium) are still maintained.

DATA FOR MIDDLE SCHOOLS

Year	Middle schools	Teachers	Students
1922–23	762	....	227,129
1923–24	764	....	221,092
1924–25	778	14,681	219,804
1925–26	780	14,830	216,552

Maturity examination certificates delivered:

	1920–21	1921–22	1922–23	1923–24	1924–25
Total	7,381	7,654	8,054	9,150	10,259
Men	5,522	5,441	5,492	6,148	6,756
Women	1,859	2,213	2,562	3,002	3,503

As I have previously mentioned, a comparison of the data concerning the number of pupils in so-called "lower" gymnasium with that of the "higher" shows the steady increase of the latter. These figures for the school years 1923–24, 1924–25, and 1925–26 were as follows:

Year	Total pupils	Lower gym.	Higher gym.
1923–24	221,092	111,583	109,509
1924–25	219,804	103,218	116,586
1925–26	216,552	93,990	122,562

During the school year 1925–26, Poland had 780 middle schools with 216,552 pupils. In 674 of these schools Polish was the language of instruction. Polish was the mother tongue of only 188,189 students. 136,516 of the pupils were boys and 80,036 were girls.

The data concerning the religions of the scholars in middle schools prove very interesting. The proportion of Roman-Catholic students in the middle schools is almost the same as the proportion of Roman Catholics in the Polish Republic. The proportion of Evangelical students exceeds a little the proportion of members of Evangelical churches in Poland. The proportion of Greek-Catholic and Orthodox scholars in the gymnasiums is less than the corresponding proportion of inhabitants of these religions in the Polish Republic. The difference between the proportion of Hebrew scholars and the proportion of Jews in Poland is markedly great. This state of things results from the fact that the Jews are living in towns and are to a certain degree richer than members of other religious sects. According to the population's roll of September 30, 1921, and the statistics for 1925–26, these proportions were as follows:

Religion	Sept., 1927, in Poland	1925–26 in middle schools	
	%	No.	%
Roman-Catholic	63.7	149,870	69.2
Greek-Catholic	11.0	9,274	4.3
Evangelical	3.2	8,575	4.0
Greek-Orthodox	11.5	6,162	2.8
Hebrews (Jews)	10.5	41,998	19.4
Miscellaneous and unreported		673	0.3
		TOTAL 216,552	

The Polish Army is also an important field of instruction. According to the bill of July 21, 1919, one thousand hours are reserved for completing the education of recruits, especially for teaching illiterate soldiers. Soldiers leaving the army must know how to read and to write. Thus the deficiencies left by the annexing governments are repaired. In 1926 there were 2570 special schools for soldiers with 6042 departments and 95,133 scholars. The teaching staff numbered 3514 persons. All military formations have special officers called "reviewers of culture and instruction," in whose control lies the teaching of the soldiers.

Special professional schools have different organization forms. There still exist some of the pre-war schools, as for instance, Wawelberg's and Rotwand's Engineering School situated at Warsaw. This school is divided into departments such as we find at the Polytechnic. Students who are graduated from this school, and then continue with short supplementary studies abroad (not longer than two years), obtain the degree of engineer. Certain schools accept pupils who have completed the common school and have passed the introductory examination; others accept those who have

completed six classes of gymnasium and have passed the introductory examination. Statistics in possession of the School Department are not complete enough to warrant citation here.

The higher instruction in Poland, *i. e.*, universities and high schools of a university level, existed before the war only in the former Austrian annexed region (Universities of Lwow and of Krakow, Polytechnic Veterinarian Academy and Agricultural Academy). In the former Russian annexed region there existed in Warsaw a Russian University, a Polytechnic, and three private high schools of a university level: the private High School of Commerce, the High School of Rural Economy, and Courses of Society of Science, the latter having been changed into the Free University. The cost of carrying on these private schools fell upon the Polish Society. When the Germans entered Warsaw in 1915, they consented to give a permit for the opening of a Polish Polytechnic and University, but because of the war, the number of students in all of these schools was very small. In April, 1919, the University in Poznan was opened, which was followed in the autumn of 1919 by the opening of the University of Wilno.

The state of development of university education is illustrated by the following statistics including state and private high schools covering a period of six years:

Year	Students	Year	Students
1921–22	34,708	1924–25	37,125
1922–23[8]	38,027	1925–26	36,590
1923–24	38,483	1926–27	39,518

In the academic year 1925–26 the distribution of students according to sex in the universities was: 27,571 men, and 9019 women. In the academic year 1926–27 there were active in Poland 16 universities, polytechnics, and other schools of a university level. The numbers of students attending these respective schools were as follows:

Warsaw University, Warsaw	9,047	
Jagielonnian University, Krakow	6,492	
John Casimir's University, Lwow	6,463	
Stefan Batory's University, Wilno	2,806	
Poznan University, Poznan	3,622	
Warsaw Polytechnic School	3,827	
Lwow Polytechnic School	2,109	
High School of Rural Economy, Warsaw	837	
Veterinarian Academy, Lwow	385	
Academy of Arts, Krakow	211	
Mining Academy, Krakow	493	
The State Dentists' Institute, Warsaw	358	36,650
Private High Schools		
Free University, Warsaw	679	
Roman Catholic University, Lublin	339	

High School of Commerce, Warsaw	1,613	
High School for Exterior Commerce, Lwow	237	2,868
TOTAL		39,518

The subjects offered and the number of students studying each in the academic year 1926–27 were as follows:

Theology	712	
Law and political sciences	9,188	
Medicine	3,757	
Pharmacy	617	
Veterinary medicine	618	
Dentistry	358	
Philosophy	14,102	
Agronomy	1,768	
Engineering and communications	1,581	
Architecture	672	
Mechanics and electrical engineering	2,107	
Chemistry	879	
Geodesy	347	
Mining	493	
Arts	338	
Commercial sciences	1,850	
Unreported	131	
		39,518

Examining the state of academic studies of chemistry in the universities and polytechnic schools in Poland, we shall see that in the years 1923–27 the number of entering students newly enrolled was:

1923–24	154	1925–26	144
1924–25	175	1926–27	201

The chemical departments of universities prepare workers for scientific research in the laboratory. The same departments of polytechnic schools prepare practice workers. The completion of the program of studies, the successful passing of semester and final examinations, and the presentation of a thesis, which demands at least one-half year of work, gives the student the rights of a Master of Chemistry or Engineer of Chemistry. The presentation of a more comprehensive thesis, demanding from one and one-half to two years of work, and the successful passing of an examination based on this thesis gives the degree of Doctor of Chemistry. At present there are more candidates for the degree of Master than for that of Doctor.

In concluding this article, I would once more call the attention of the reader to the fact that progress in the school affairs of the Polish Republic is taking place throughout the entire system, from the common schools to universities.

The Polish Government and Society are extremely interested in the problem of the education of Poland's youth. Their aim is to educate a new citizen, a citizen of free and independent Poland imbued with a spirit of democracy, tolerance, and harmony. These ideals were beacons to the Polish national heroes, Kosciusko, Pulaski, and others, who shed their blood and perished fighting for the cause of freedom in the United States of America, which lies far away from Poland across the seas.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Assistant Agronomist (Sugar Technology). Applications must be on file with the Civil-Service Commission at Washington, D. C., not later than March 27th. The entrance salaries range from $2600 to $3100 a year. Higher salaried positions are filled through promotion.

The examination is to fill a vacancy in the Bureau of Plant Industry, Department of Agriculture, for duty at Cairo, Georgia, and vacancies occurring in positions requiring similar qualifications, for duty in Washington, D. C., or in the field.

The duties are operating a field station devoted to the production of sugar cane for sirup-making purposes, and the making of sirup therefrom, involving the following duties: planning and conducting varietal and cultural tests and crop rotations with sugar cane; making sirup from experimental crops of sugar cane; devising improvements in methods and apparatus for making sirup from sugar cane under farm conditions; acting in general charge of the station; and also participating in variety tests at coöperating experiment stations and at other test fields.

Competitors will not be required to report for examination at any place, but will be rated on their education, training, and experience, and a thesis or publication to be filed by the applicant.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the United States Civil-Service Board of Examiners at the post office or customhouse in any city.

Sheep's Gold Teeth Were Not Genuine. A sheep's jawbone from the lead-mining district of Scotland was found to contain teeth which had a metallic luster, and it was popularly supposed that the luster indicated a deposit of gold. However, the teeth were analyzed by the government chemist and he found traces of lead but no gold. The metallic sheen appeared to be due to the effect of light on a laminated, or flaked, crystalline structure, mainly calcium phosphate.—*Science Service*

EXHIBIT OF HIGH-SCHOOL STUDENTS' WORK IN CHEMISTRY

An exhibit of students' work in chemistry in high schools is being planned for the Spring Meeting of the Division of Chemical Education at Columbus, Ohio. All teachers of high-school chemistry are invited to prepare and send in exhibits of their work. Any inquiries regarding the exhibits should be referred to Dr. Wm. McPherson, Ohio State University, Columbus.

JOHN MAXSON STILLMAN AS A CHEMICAL HISTORIAN

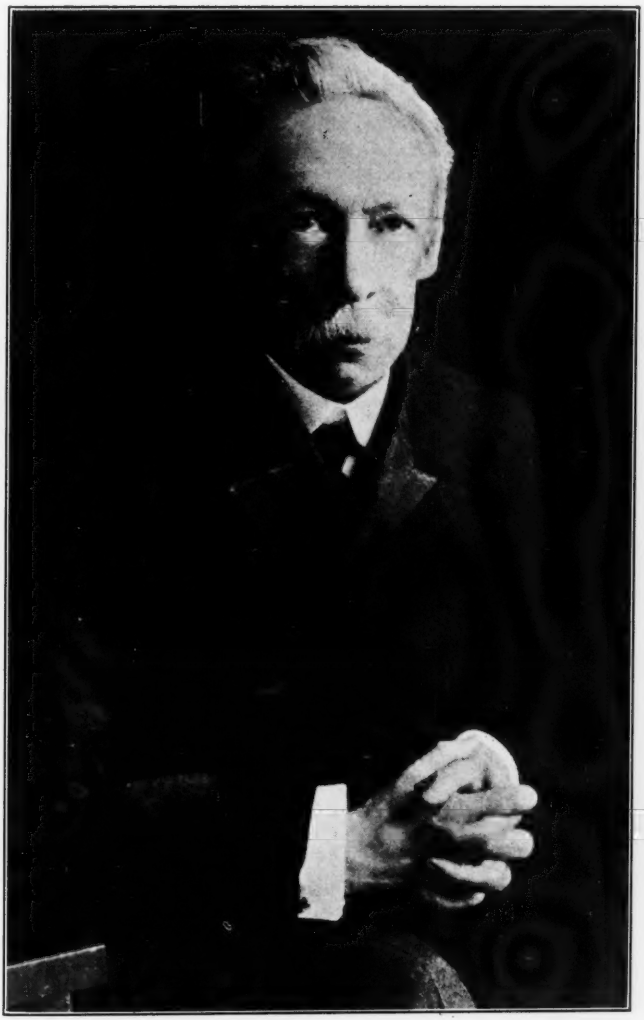
HOWARD M. ELSEY, WESTINGHOUSE RESEARCH LABORATORY, EAST PITTSBURGH, PENNSYLVANIA

The contributions of Dr. John Maxson Stillman to the science of the history of chemistry number ten papers and two books. Publications of the series did not begin until toward the close of his twenty-six years of active teaching at Stanford University and ended with his greatest effort—"The Story of Early Chemistry"—which was in the hands of the publisher at the time of Dr. Stillman's death, December 13, 1923.

Both the location of Stanford University and the youth of its library served to deny him access to many of those literary treasures whose study is essential to original work in the field of early chemical history. Perhaps it was this lack of source material which limited the number of his wholly original contributions in this field.

During the last fifteen years of his active academic service he taught a class in the history of chemistry. This class was always small in the number of students enrolled and was conducted in a highly informal fashion. The writer numbers among the pleasantest hours of his own student days those spent while listening to Dr. Stillman's interesting discourses in this class. As a part of the term's work each student prepared several papers on assigned topics and reported in turn toward the close of the semester. An assignment called for the review of one or more old books on chemistry, the books usually being loaned from the personal collection of Dr. Stillman. Mere contact with these venerable and musty tomes was in itself inspiring, and perusal of the contents brought an acquaintance with the life and spirit of the older schools of chemical thought which never could have been gained from a modern textbook. Educational and inspiring it admittedly was, but this method of teaching did have its faults. It was sometimes extremely expensive. Actual physical contact with these old books sometimes led to a desire to possess similar treasures and book-collecting is indeed an expensive habit.

Despite the smallness of the class there was none of that oft-met-with laxity in preparation on the part of the instructor. Preparation involved not only entire familiarity with the current textbooks but careful scanning of all scientific papers, monographs, and encyclopedic handbooks published on the subject since the history of our science became recognized as a distinct branch of chemical learning. Under his guidance the university gradually acquired a working collection of the authorities and his own collection of older books became sufficiently extensive to have excited the envy of all true booklovers in our chemical fraternity. It was this intimate familiarity with the literature of the subject which brought forth his first published contribution in this field. In these days of hasty and feverish



JOHN MAXSON STILLMAN

printing we might note that Dr. Stillman's first paper on the history of chemistry followed rather than preceded ten years' teaching of that subject.

This paper was entitled "Basil Valentine: A Seventeenth Century Hoax."[1] In it were discussed the relative merits of the contributions both of fact and theory of Paracelsus, and the person writing under the name of Basil Valentine. We may summarize the paper briefly as follows.

For two hundred years there was an increasing tendency among chemists to assume that Paracelsus had had access to and had borrowed freely from the writings of Basil Valentine without giving any credit to him. During his lifetime Paracelsus had incurred the enmity and hatred of the orthodox medical profession by his bitter attacks both on their knowledge and ethics. Warfare between his followers and the older school continued for a century after his death. In the midst of this contest the writings of the supposed Basil Valentine were published. Almost immediately the great similarity in their content to the works of Paracelsus was noted and, as the editor of Basil Valentine, Johann Tholde, claimed to have copied the writings from old difficultly decipherable manuscripts. The Galenists, eager to detract from the reputation of Paracelsus by any means, at once accused him of plagiarism. The truth of Tholde's statements regarding the manuscripts went practically unquestioned until the latter half of the nineteenth century. Largely through the efforts of the German chemist, Kopp, the following facts were established. First, there is no evidence that any one had ever heard of Basil Valentine before 1603 when publication of his writings began and at which time all of the work of Paracelsus had been in print for ten years or more. Though Basil Valentine himself claims to have been a monk of the Benedictine order, the records of the order fail to show the existence of such a brother. Second, no reference dated before 1603, either to him or to his work, has ever been found in the writings of other authors. Third, no original manuscript has been placed in evidence at any time. Fourth, while internal evidence in the books fixes the earliest possible date of writing as the last of the fifteenth century, no evidence other than that of the unsupported word of Tholde, their editor, has placed them as being earlier than the date of publication. Fifth, in 1603 Tholde published under his own name a work which he again published in 1644, but this time as "Ex manuscriptis et originalibus Fratri Basilii Valentini ordinis S. Benedicti collecta." Tholde also is under suspicion of having forged and published a manuscript which he claimed had been written by Paracelsus. All of which evidence conclusively shows that the Basil Valentine literature has no place in the true history of chemistry other than as a summary of the chemical knowledge of the period in which it was written, namely, the early seventeenth century.

The above conclusion and the evidence on which it was based were not

[1] *Pop. Sci. Mo.*, **84**, 591 (1912).

original with Dr. Stillman. The final weighty summary of these views was made by Kopp[2] in 1886 and his opinions have been concurred in by many other writers since that time.

Since this is true, we may ask why Dr. Stillman felt it necessary that these arguments again be published in a scientific paper of his own. The answer is that, while the more voluminous German monographs and texts on the history of chemistry and alchemy had replaced Paracelsus in his rightful position as an original thinker and contributor to the chemistry and medicine of his day, still at the time this paper was published in 1912 the textbooks available for an English reading class had incorporated none of these newer findings in their text.

The writer is reviewing the above paper at some length because even today the Basil Valentine myth persists. He is treated as a real person in the most widely used American textbook on the history of chemistry,[3] this book being published in 1918. Two well-known handbooks of physics and chemistry[4] credit him with the discovery of several of the elements, all of which illustrates the old saying that a lie once uttered can never be overtaken by the truth.

In his second paper, "The Dawn of Modern Chemistry,"[5] Dr. Stillman first summarizes the generally accepted theories and knowledge extant in chemistry at the beginning of the sixteenth century. Then follow sketches of the lives and work of the four men who, each in his own special field, are credited with initiating the great revival in chemical activity. Chemistry, with her sister sciences, had been slow to feel the intellectual stimulus of the Renaissance, but with the appearance of these men—Paracelsus, Agricola, Biringuccio, and Pallisy—comes "The Dawn of Modern Chemistry." This period of tremendous advances was to end only with the beginning of the modern era which was to commence with Lavoisier. It was this period which saw the first officially recognized professor of chemistry in Germany in 1629 and the first chemical laboratory at any European university, the University of Leyden. Of the four men who began this era, Agricola, Biringuccio, and Pallisy laid the foundations of modern chemical technology.

While the greatest service of Paracelsus was to shatter confidence in dogmas revered for the sake of their authors' great names, the new doctrines which he set up to replace the dogmas he combated were, in many respects, as fantastic and unscientific as the earlier ones. Nevertheless, the shattering of the blind faith in traditional teachings, which gave to Paracelsus his popularity and following, necessarily operated also to

[2] *Die Alchemie*, **1**, 29–33 (1886).

[3] Moore, "A History of Chemistry," McGraw-Hill Book Co., New York, **1918.**

[4] Kaye and Laby, "Physical and Chemical Constants," Longmans, Green & Co., London, **1921**; Hodgman and Lange, "Handbook of Physics and Chemistry," The Chemical Rubber Co., Cleveland, **1924.**

[5] *Pop. Sci. Mo.*, **87**, 5 (1915).

prevent his new doctrines from being considered as sacred or infallible. Free criticism and independent thought once aroused could not again be contented with blind adhesion to any unchanging system of doctrines.

The next paper, "The Contributions of Paracelsus to Medical Science and Practice," was the first of a series of five.[6] In 1920 these essays with added chapters were issued as a monograph on the life and work of Paracelsus.[7]

Apparently Dr. Stillman very early acquired a deep admiration for the personality and work of Paracelsus. That this should be so seems strange. One would hardly expect Paracelsus, rash, hasty-tempered, arrogant, and egotistical as he certainly was, to have any appeal to such a kindly, courteous, even-tempered gentleman as our Dr. Stillman. The one was a radical breaking loose from all traditions; the other was essentially a conservative by nature. We might expect to hear nothing but condemnation of Paracelsus. On the contrary, we find in the book a most admirable defense of him. His faults are freely admitted, but these are more than counterbalanced by his truly great contributions both to the spirit and facts of science.

The series of essays on Paracelsus was interrupted by a short paper on "Chemistry in Medicine in the Fifteenth Century."[8] Here especial attention is paid to the "Liber Distillandi" of Brunschwygk with further short notes on the rise of Iatrochemistry.

The paper "Falsifications in the History of Early Chemistry"[9] makes "no pretension to a complete account of falsifications in the early history of chemistry, but comprises the most notable instances" and will serve "to illustrate the difficulties that have attended the story of the development of chemical science and the misapprehensions affecting the reputations of early scholars in science."

Dr. Stillman's last scientific paper[10] is important as containing an entirely new piece of evidence in chemical history. An Italian called Petrus Bonus wrote an elaborate treatise on alchemy, the work bearing the date of 1330. This work proved quite popular after printing began and it was in one of the later editions of this that Dr. Stillman's study uncovered a point which had been overlooked by the many early chemical historians who have studied the book and referred to it in their writings. The argument may be best presented by selected quotations from Dr. Stillman's paper.

[6] *The Monist*, **27**, 390 (1917); *Ibid.*, **29**, 106 (1919); *Ibid.*, **29**, 526 (1919); *The Open Court*, **33**, 740 (1919); *Ibid.*, **33**, 169 (1919).

[7] "Theophrastus Bombastus von Hohenheim called Paracelsus," The Open Court Publishing Co., Chicago, **1920.**

[8] *Sci. Mo.*, **6**, 169 (1918).

[9] *Ibid.*, **14**, 560 (1922).

[10] *Ibid.*, **17**, 318 (1923).

Examination of the text of the "Preciosa Margarita" shows that Bonus based his discussion, not upon any recorded experience of his own, but upon a careful and conscientious digest of all authorities known to him. He very systematically cites these authorities to justify his statements, and nearly all these authors he cites several times, and some of them many times. Names of writers upon alchemical philosophy mentioned by Bonus comprise nearly all those whose works were referred to in the encyclopedic works of Vincent of Beauvais, Albertus Magnus, Bartholomaeus Anglicus, and Roger Bacon in the thirteenth century, and notably one important authority later than these—Geber, much cited by Bonus. The name of Geber is mentioned at least forty-one times in the Margarita.

The references to Geber are to his "Summa Perfectionis Magisterii," his first and principal work, which was supposed to be derived from the Arabian of the True Geber of the eighth or ninth century A.D., but appeared after 1300 A.D. and is now known to have been originally written in Latin at about the time it was issued, 1300.

Especially notable is the fact that Bonus makes no mention of Albertus Magnus, Thomas Aquinas, Roger Bacon, Arnald of Villanova nor Raymond Lully. Considering the fact that in 1330 these authors had been dead for from fifteen to more than fifty years, and the high reputation that these authors enjoyed as alchemical philosophers and operators in the fifteenth and sixteenth centuries, the absence of these names from Bonus' list of authorities, otherwise so comprehensive, certainly demand explanation.

It does not seem at all probable that these prominent authors wrote articles on alchemy, and that yet these articles should have been concealed for from a quarter to half a century before bursting on the alchemical public.

The reasonable assumption on the basis of all present information is that the Margarita was correctly dated, shortly after Geber's "Summa" had appeared, and that at that time the alchemical works attributed to Thomas Aquinas, Albertus Magnus, Roger Bacon, Raymond Lully and Arnald of Villanova were not known to Bonus, because they were not yet written, being forgeries of periods considerably later than the lives of those authors to whom they were ascribed.

Aside from the evidence which is presented so logically in its pages this last paper of Dr. Stillman is of value to us for two reasons. First, it shows us the character of the man. The work of Bonus has been commented on and evaluated by most of the early historians. Most of us knowing this and having access only to one of the later editions[11] would have given the book only a casual inspection, but Dr. Stillman bestowed on it that same painstaking care which characterized all his reading and which denotes the true scholar. As a result we have an important piece of independent evidence brought to light concerning the history of the period in question. Second, it arouses the hope that others who, like Dr. Stillman, are far removed from manuscripts and a wealth of first editions may find similar rewards awaiting equally careful study of those early works which are still readily available.

"The Story of Early Chemistry"[12] has been reviewed[13] as appealing . . . to teachers and advanced students in chemistry. To the former it will give a vast fund of facts usable in the course of their class instruction while to the latter it offers

[11] Mangetus, *Bibliotheca Chemica*, Geneva, **1702.**

[12] D. Appleton & Company, New York, **1924.**

[13] E. F. Smith, THIS JOURNAL, **2,** 95 (Jan., 1925).

source material for a more exhaustive study. But it lacks that personal touch which to the writer means so much in all chemical instruction.

To the present writer it seems that it is just this lack of a personal touch which gives the volume its greatest value. In a book designed as a source book it is necessary for an author to maintain a judicial impartiality in controversial matters and with the interjection of a personal touch it is often difficult to eliminate personal prejudice. The text is replete with carefully selected quotations from early and inaccessible works. It is a distinct contribution to chemical literature and stands as a fitting memorial to its author, that delightful and well-beloved gentleman and scholar, John Maxson Stillman.

Lining Hydrochloric Acid Tanks. One of the most urgent needs of the chemical industry is a constructional or reënforcing material that will withstand the action of hydrochloric acid when concentrated and hot. After much experiment it has been found that it is possible to produce a soft compound which neither contracts nor expands over quite a wide range of temperature, which has a high resistance to corrosion, and which can be applied in an unvulcanized condition, being molded into shape with the application of heat. This new material, made by the St. Helens Cable and Rubber Co., Ltd., of Slough, under the name of "Cabtyrit," is derived from "Cabtyre," the well-known electrical insulator which is greatly in use in acid-laden atmospheres. "Cabtyrit" is a dense compound of specific gravity 1.0. It softens and becomes plastic at about 25°C., and can be worked and molded into shape. "Cabtyrit" resists the action of hydrochloric acid and its solutions at all strengths and temperatures up to 110°C., for which purpose indeed it was specially evolved. It has also been found to withstand the action of most organic acids, such as tartaric, citric, lactic, malic, and formic acids, and also of phosphoric acid and of cold sulfuric acid up to 80 per cent, and of hot vitriol at strengths not exceeding 60 per cent. It is not recommended for nitric acid, though weak solutions of nitric acid do not affect the new material. Solutions of "Cabtyrit" can be applied as paints and sprays to iron surfaces, and thus form a convenient paint for the internal surfaces of large water and weak-acid liquor tanks. Being a heavy compound, "Cabtyrit" can be vulcanized in a crude manner, which enables intelligent labor to fashion pipes and fittings with the plant usually found in an ordinary works.—*Chem. Age*, **19**, 394 (Oct. 27, 1928).

Salt in Canada. An increase of 60 per cent in the production of Nova Scotia salt mines is recorded for the past year, the output being 20,000 tons, as against 12,500 tons for the previous twelve months. Last summer Malagash Salt Products, Ltd., placed in operation an up-to-date evaporating plant consisting of three pans with a daily capacity of 15 tons. This enabled the company to place upon the market an evaporated salt of very fine quality which immediately met with the favor of consumers. The Premier of Alberta reports that two substantial groups of industrialists are making inquiries relative to the salt deposits recently discovered in Northern Alberta at Waterways, the present northern terminal of the Alberta and Great Waterways Railway. At this point drillers recently tapped a 200-ft. bed of salt, declared by the *Provincial Analyst* to be 99 per cent sodium chloride. Three samples brought down from the well were found to have a strength of slightly over one and a half pounds per gallon.—*Chem. Age*, **20**, 27 (Jan. 12, 1929).

THE PREPARATION OF LARGE CRYSTALS OF CHROME-ALUM AND INTERPRETATION OF SOME ETCH FIGURES

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Introduction

Large crystals have always had a fascination for many people because of their symmetry and regularity. The English crystallographer Tutton once remarked that the beauty of crystals lies in the planeness of their faces. The artist Dürer shows a crystal in his famous etching Melancholia, indicating that he considered the structure of solids a problem of equal philosophical importance with that of the magic square and the motion of the stars. In recent years the application of x-ray methods has been tremendously fruitful in the solution of crystal problems. There is also a demand for large crystals of many kinds for studies of the piezo-electric effect and for crystal oscillators in radio work and for parts of optical systems.

In the fall of 1926 some chrome-alum crystals were desired for a special problem and one of the authors (F. A. R.) set out to make them. Formation of the crystals by evaporation at the boiling point was unsatisfactory because of the fact that there is a transformation from the greenish violet modification to the high temperature green type at 78°C. Above this temperature the green type is formed. The general formula for the alum group is $XY(SO_4)_2 \cdot 12H_2O$ where X is a univalent and Y a trivalent positive ion. Chrome alum may be thus written $KCr(SO_4)_2 \cdot 12H_2O$, or as the double salt $K_2SO_4 \cdot Cr_2(SO_4)_3 \cdot 24H_2O$. Wyckoff has shown that the chrome-alum crystal belongs to the pyritohedral class of the cubic system. The unit cell consists of a cube containing 4 K atoms and 4 Cr atoms, the 2 metals alternating. Each one of the metal atoms is surrounded by 6 H_2O molecules. The 8 SO_4 ions form the corners of a smaller cube placed symmetrically within the other cube, that is, with its faces parallel to those of the larger cube. The formula for the unit cube is thus $4[KCr(SO_4)_2 \cdot 12H_2O]$.

Preparation of Large Crystals

The chrome-alum was most conveniently prepared by bubbling sulfur dioxide gas through a concentrated solution of potassium dichromate and taking care that the temperature did not rise above 78°C. A solution saturated at about 40–50°C. was allowed to cool slowly, precipitating out some small crystals. The largest of these were selected and placed in crystallizing dishes containing fresh saturated alum. At first there was considerable difficulty because a slight increase in temperature would dissolve the small crystals completely, while a too rapid evaporation would promote precipitation of other nuclei and the result is a layer

of fine crystals. No threads or strings were used at any time. After the crystals had reached the 5- or 10-gram stage there seemed to be a marked tendency for twinning. Small nuclei frequently appeared on the surface. These were scraped or washed off and the growing continued by transferring the crystals every day or so into fresh saturated solution, and turning them over if they seemed unsymmetrical in the development of their faces. It is interesting to point out that if a corner is knocked off it will be very rapidly repaired by contact with a saturated solution. The phenomenon of twinning, however, is merely a temporary maladjustment of the facial growth. The homeliest crystal, if allowed to grow, will eventually revert to its normal form, octahedral in this case. After the crystals have grown for several months in a basement room where the temperature shows little variation they cause little trouble. If dust is kept out of the dish no nuclei will develop and the large crystal seems to domineer the surroundings, taking all the growth to itself. We have one crystal which has grown sixteen months and weighs 700 grams, and measures 5 inches from tip to tip. Another one, about twelve months' old, weighs about 500 grams.

Measurement of Facial Angles

The octahedral face has a Miller index 111. That is, if we imagine x, y, and z axes passing through the crystal, one face will intersect the 3 axes 1 unit from the origin. Since there are eight possible arrangements of the numbers 111, namely, 111, $11\bar{1}$, $1\bar{1}1$, $1\bar{1}\,\bar{1}$, $\bar{1}11$, $\bar{1}1\bar{1}$, $\bar{1}\,\bar{1}1$, $\bar{1}\,\bar{1}\,\bar{1}$, the crystal will be octahedral. A cubic crystal has the Miller index 100. The six possible arrangements are 100, 010, 001, $\bar{1}00$, $0\bar{1}0$, $00\bar{1}$. The plane 100 intersects the x axis at 1 unit and the y and z axes at $1/0$ and $1/0$, namely, ∞. It is thus parallel to these 2 axes. The Miller indices of a plane are defined as the reciprocals of its intercepts upon the x, y, and z axes.

Measurements made on our largest crystal showed the angle between the 111 and the $1\bar{1}1$ planes to be 70° 31′ 44″, and the angle between the 001 and the 111 plane to be 54° 44′ 8″.

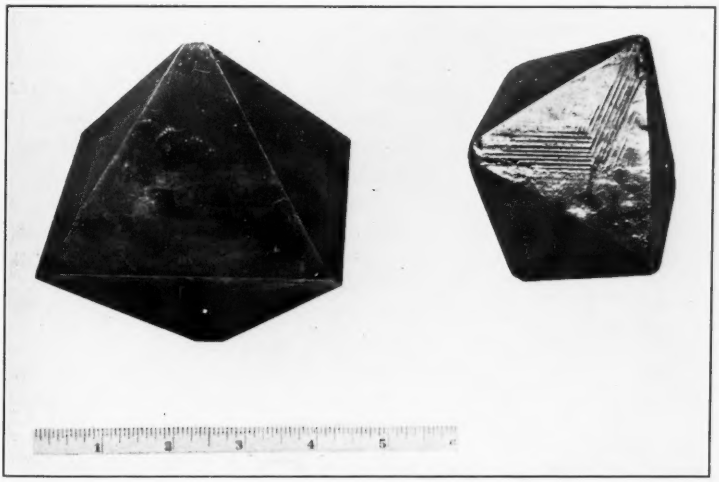
Etch Figures

When an octahedral crystal of chrome-alum is placed in a slightly undersaturated solution at room temperature striations gradually develop on some of the faces. These striations are exactly parallel to the bisector of the 60° angle of the equilateral triangle which forms the octahedral plane, 111. Under certain conditions two sets of such lines may be formed and one case was observed where all three angles of the face were bisected by lines of this type, although the three sets of lines were not equally developed. The photograph shows these lines intersecting at an angle of 120°. Upon examination under a binocular microscope of about 30 magnifications these striations are seen to consist of alternately projecting and entering dihedral

angles with edge faces about 1 mm., so that a cross-section would show such forms as in Figure 1, or a combination of these forms.

FIGURE 1.—POSSIBLE FORM OF ETCH GROOVES

Rotation of the crystal under the microscope in an oblique light shows the facets a_1, a_2, a_3, etc., light up at the same time and therefore they seem to be definitely parallel to one another. Similarly, facets b_1, b_2, b_3, etc., seem to be parallel to each other and to the octahedral plane which is etched.



CHROME-ALUM CRYSTALS

It is of interest to speculate upon the nature of these etchings. Does a solution attack a crystal in a uniform fashion or in a chaotic irregular fashion, or does the architecture of the crystal govern the manner in which the breakdown occurs? The knowledge of the inner structure of crystals which x-rays have given leads us to expect that the form of etch figures is a very definite consequence of the crystal lattice. In support of this idea we have the fact that the striations are exactly parallel to the bisector of the equilateral triangle of the 111 plane. Also, similar facets seem to be parallel.

A crystal of chrome-alum, which has the symmetry of pyrite, may develop the following simple forms or combinations of them:

1. Cube, Miller index 100.
2. Octahedron, Miller index 111.
3. Simple dodecahedron, Miller 110.
4. Pentagonal dodecahedron, each face a pentagon, with Miller index commonly 210, 310, 420, or 320.
5. Diploids (421), trisoctahedrons (221), and trapezohedrons (211) may also be formed.

It is therefore obvious that an octahedral crystal when etched may develop any of the planes 100, 410, 310, 210, 110, 320, etc. Development of the cube faces 100 would mean that the tetrahedral edges or corners would be truncated. We found that the corners were attacked by the solution but that the new planes were not sufficiently well formed to be identified; on the other hand, the fact that the 60° angle of the octahedral (111) plane is bisected indicates that the two facets (*a* and *c*) on opposite sides of the groove formed by the etching have the same Miller index, *e. g.*, (20)1 and (02)1 or (21)3 and (12)3 rather than (21)1 and (13)1 or (21)1 and (14)1. The latter situation would develop two sets of parallel striations converging at each corner of the equilateral triangle.

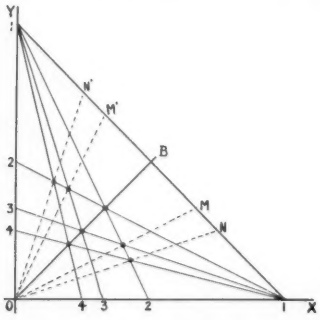


FIGURE 2.—SECTION THROUGH CRYSTAL ON *OXY* PLANE

Line *XBY* represents edge of crystal. Planes 211 and 121; 311 and 131; 411 and 141 intersect on line *OB* and therefore a groove would be formed on face of crystal joining *B* to point $Z = 1$ on *OZ* axis. Intersection of planes 211 and 131 forms a groove joining $Z = 1$ to *M*, etc.

If the planes of simplest index are those developed by etching one might expect the facets *a* and *c* to be *pyritohedral* planes 201 and 021 appearing on the 111 plane. These planes would each form an angle of 39°14′ with the 111 plane. In support of this hypothesis we have the statement in Dana's "Mineralogy" that "cubic crystals of pyrite (which has the same symmetry as chrome-alum) are commonly found with striations parallel to the alternate edges and due to the partial development of the pyritohedral faces 210." We hope in the near future to obtain accurate goniometer measurements on these facets.

If a detailed examination of a groove shows it to be "rounded" it will mean that not only the planes 210 are formed but that several others are present, possibly in the order 111, 201, 211, 111, 121, 021, 111, as in Figure 4. There is indeed some evidence of this rounding when the crystal is allowed to grow after having been etched. It indicates a definite surface tension of the crystal tending to make its surface at a minimum just as a drop of liquid assumes the spherical form.

The phenomenon of etching of crystals has long been familiar to the mineralogist who has often used the characteristic figures as a criterion for identification of microscopic specimens. The classical treatise on the subject is Baumhauer's "Die Resultate der Aetz-Methods in der Krystallographischen Forschung," published in Leipzig in 1894. The best text in the English language on this subject is "Etch Figures on Crystals," by A. P. Honess, published by John Wiley and Sons, 1927. As far back as 1808, a study was made by Widmannstätten of the characteristic markings produced by acids on the polished surfaces of meteorites. Very little attention was paid to pure crystals in the early days but as time passed the term "Widmannstätten figures" came to be applied to some degree also to etched figures on crystals. *When polished surfaces of metals or other objects are etched, however, the figures developed are not capable of any simple interpretation unless the surface happens to be a natural crystallographic plane,* and as already pointed out the striations are different in the different crystal faces. For about 80 years the development of the science of etching crystals was largely in German hands, particularly Baumhauer, Klocke, Hamberg, Ebner, Rinné, Traube, Tschermak, Viola, Beckenkamp, and Wulff. As stated by Honess, "the general content of these papers comprises a theoretical study of the etch figure in connection with extensive experimental work, involving the etching of many of the commoner minerals. Such topics as asterism, the importance of the etch figure in isomorphism, the rational or irrational character of the axial intercepts of etch faces, differential solution as exhibited by natural crystals and ground spheres, anomalous etchings, the relation of the etch figure to the crystalline molecule, the conditions governing the development of the etch figure, and its relation to the symmetry content of crystals are discussed in Baumhauer's work."

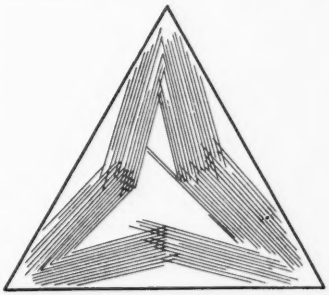


FIGURE 3.—SIX SYSTEMS OF ETCH LINES

Formed on the octahedral face by grooves with facets 211 and 141, 121 and 411, 121 and 114, 112 and 141, 211 and 114, 112 and 411.

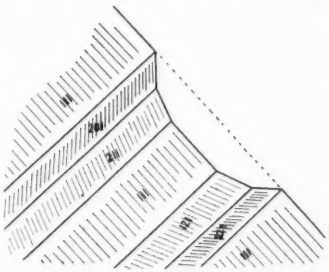


FIGURE 4.—DETAIL SKETCH OF "ROUNDED" GROOVE

Made up of several planes so that the crystal surface may approach a minimum.

The evidence of the etch method clearly shows that crystals have different solubilities in different directions. A quantitative treatment of the problem is still in its infancy because large crystals must be found or grown in order to get etch facets large enough for measurement. The authors believe that chemists will derive a great deal of pleasure and insight into crystal structure by growing large crystals and working out explanations of the corrosion figures.

Summary

A technic is described for the preparation of large octahedral chrome-alum crystals, and a study made of the etch figures formed when these crystals are allowed to dissolve slowly.

References

Dana, "A Textbook of Mineralogy," John Wiley and Sons, New York, p. 45, **1904.**

Wyckoff, "The Structure of Crystals," Chemical Catalog Co., New York, p. 362, **1924.**

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New Fumigant for Stored Products. Ethylene oxide is a fumigant not hitherto used for exterminating insects, but recently discovered by the United States Department of Agriculture to be highly toxic to certain species. Those commonly infesting stored food products, clothing, and furniture can, it is stated, be easily killed by the vapors of ethylene oxide in concentrations that can be used without danger from fire and that are not dangerous to human beings. Clothes moths, carpet beetles, rice weevils, saw-toothed grain beetles, Indian meal moths, red-legged ham beetles, and flour beetles all succumbed to this new fumigant when it was used experimentally for a period of 20 hours in the proportion of 1 lb. of ethylene oxide to 1000 cubic feet of space. For commercial fumigation work, the Department of Agriculture, however, recommends that the fumigant be used at double this quantity per 1000 cubic feet of space. Comparative tests indicated that the vapors of ethylene oxide are somewhat more toxic to stored-product insects than are those of carbon disulfide and about thirty times as toxic as those of carbon tetrachloride.

Owing to its low boiling point, ethylene oxide is effective at comparatively low temperatures, ranging from 60° to 75°F. It has excellent powers of penetration. Insects buried in over-stuffed furniture, sealed in packages of cereals, and buried in jars of grain were killed with ease. No deleterious effect was noticeable when the commercial strength of the fumigant was used for 24 hours on commodities such as foodstuffs of various types, clothing, furniture, and metals. Such foodstuffs as nut meats and dried fruits were unaffected, and no foreign taste or odor was discernible after removal from the fumigation chamber. No liquid foods were treated. Preliminary tests in a vacuum fumigation tank show that ethylene oxide can be successfully used for this type of fumigation. Seeds for planting purposes, however, should not be fumigated with ethylene oxide, since the vapors seriously affect the germination. Wheat was used for the germination experiments.—*Chem. Age*, **20,** 99 (Feb. 2, 1929).

OXIDATION-REDUCTION REACTIONS

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Historical

The reactions of inorganic chemistry are those of metathesis or oxidation-reduction. Metathesis usually involves the formation of a precipitate, a gas, a slightly ionized substance or a complex; oxidation-reduction covers those reactions in which the valence, or more properly the polarity, of an element changes. These last reactions are very important, both in mineral chemistry and in the chemistry of the carbon compounds. Even life itself is largely a matter of oxidation and reduction, for we breathe oxygen into our lungs whereby the ferrous iron of the blood is oxidized only to be reduced again as the blood passes through the body. On account of the importance of such reactions it is not surprising that considerable attention should be paid by all teachers to methods of writing mathematical equations to express oxidation and reduction; a number of papers have been published recently on this subject and one of these has been elaborated and published in book form.[1]

All these recent writers agree that an oxidation does not necessarily have anything to do with the element oxygen and the term *adduction* has been suggested to replace the word oxidation, signifying that the polarity of an element has been increased in the negative to positive direction. In other words, oxidation now means the loss of one or more particles of negative electricity (electrons) by an atom of the substance oxidized. Oxidation-reduction reactions merely represent an electrical exchange, the reduced substance accepting one or more electrons from the oxidized one.

The idea of valence being of electrical nature undoubtedly originated with the celebrated Swedish chemist, J. J. Berzelius (1779–1848), who assigned to every atom two poles like those of a magnet. According to Berzelius, chemical combination depends entirely upon the effects of these positive and negative poles. Every compound, according to Berzelius, can be divided into a positive and a negative constituent. Moreover, Berzelius distinguished between positive oxides like Na_2O, and negative oxides like SO_3. Bases, as we now know them, were positive oxides and water; acids were negative oxides and water; while salts were positive oxides combined with negative oxides. This so-called "dualistic theory" is regarded as the forerunner of the electrochemical theory which prevails today. Even some of our recent literature cannot be understood unless

[1] S. R. Brinkley, THIS JOURNAL, **2**, 576 (July, 1925); J. Waldbauer and W. E. Thrun, *Ibid.*, **3**, 1430 (Dec., 1926); J. H. Simons, *Ibid.*, **3**, 1305 (Nov., 1926); E. R. Jette and V. K. La Mer, *Ibid.*, **4**, 1021, 1158 (Aug. and Sept., 1927); W. M. Hoskins, *Ibid.*, 4, 1013 (Aug., 1927); H. L. Lochte, *Ibid.*, **4**, 223 (Feb., 1927).

one is somewhat familiar with this theory. Thus, in mineral analysis, it is still customary to report the results in terms of basic and acidic oxides, and frequently a statement is made that FeO is oxidized to Fe_2O_3 when it is merely meant that a ferrous salt has been changed to a ferric one.

The dualistic theory dominated our ideas of oxidation and reduction for about 100 years. Even today, sometimes, beginners are taught to write equations of oxidation-reduction in the old-fashioned way of making a series of preliminary equations, referring the change to the oxides. Thus, in terms of the dualistic theory, the oxidation of ferrous chloride by chlorine water would be written:

$$\begin{aligned} 2FeCl_2 + 2H_2O &= 2FeO + 4HCl \\ Cl_2 + H_2O &= 2HCl + O \\ 2FeO + O &= Fe_2O_3 \\ Fe_2O_3 + 6HCl &= 2FeCl_3 + 3H_2O \\ \hline 2FeCl_2 + Cl_2 &= 2FeCl_3 \end{aligned}$$

Each of the four preliminary equations is as difficult to understand as the final equation considered alone.

The idea of abolishing the dualistic method of writing oxidation-reduction equations and balancing by the *change in valence* method appears to have been first published in 1880 in a paper by Otis Coe Johnson as a part of Douglas and Prescott's "Qualitative Analysis." Particular attention is called to this part of the book on the title page and in the preface. Later editions of the book bear the names of Prescott and Johnson as authors.

Johnson's theory of oxidation-reduction is strikingly similar to the most modern views; so much so, in fact, that when the electron theory was first enunciated every teacher who had been using Johnson's method of writing equations at once saw the application of the electron theory to oxidation-reduction reactions. To be sure, Johnson emphasized *negative bonds* but what he said about negative bonds can be said of what we now call *electrons*.

At the time Johnson wrote his paper, valence had been regarded merely as a positive number by many who had discarded the dualistic theory, although Abegg, in his valence theory published a little later, speaks of positive and negative valences probably without knowledge of Johnson's ideas. There is less danger of misunderstanding if in oxidation-reduction reactions the term *polarity* rather than valence is used. Johnson obviously had this in mind. According to Johnson an oxidation always represents an increase in polarity in the negative to positive direction and a reduction, which always accompanies an oxidation, is a change in polarity in the positive to negative directions. Hydrogen, in all its compounds, is as

sumed by Johnson to have a polarity of +1, oxygen (except in peroxides) a polarity of —2, and a free element always has the polarity 0.

Actual experiments with thousands of students have shown two things; (1) beginners find the *change in polarity* method of balancing equations of oxidation-reduction much easier to understand than the older, dualistic method of tracing the oxidation back to typical oxides;[2] (2) beginners find it a little easier to use *ions* rather than whole molecules in writing these equations.

Johnson regarded molecules themselves as neutral. Thus, SO_3 and Na_2O were regarded as saturated molecules and not as negative or positive oxides. If these combine to form Na_2SO_4, there is no change in polarity of either Na, S, or O and this is in accord with Werner's valence theory. Similarly when NH_3 unites with Cu^{++} to form $Cu(NH_3)_4{}^{++}$ there is no change in polarity. Polarity therefore corresponds to the *principal valence* of the Werner theory.

Typical Reactions

In balancing reactions of oxidation-reduction, the only logical method is first to balance the oxidant with the reductant. Thus, in the oxidation of a ferrous salt by potassium permanganate in the presence of dilute sulfuric acid, it is misleading to attempt to balance the permanganate with the acid and then work with the ferrous salt, as some have done. In order to make it clear how the ideas of Johnson would be interpreted in the light of the electron theory, a number of typical reactions will be given.

(1) **The Electrolysis of Dilute Sulfuric Acid.**—This experiment is given in many elementary texts on both physics and chemistry. The migration of the ions from one electrode to the other is always explained correctly. In dilute sulfuric acid, H^+ and SO_4^{--} are present in abundance while the concentration of OH^- is inappreciable. Therefore the positively charged H^+ ions migrate toward the negatively charged cathode and the negatively charged SO_4^{--} ions toward the positively charged anode. At the cathode, H^+ ions are discharged, not because they have carried the current across the electrolytic cell, but because it is easier to reduce these ions than the S of SO_4^{--} and S is the only other element capable of reduction that is present. At the anode, however, there are two possibilities, either negatively charged oxygen will be changed to neutral oxygen, or the oxidation will result in the formation of persulfuric acid. In the case of *dilute* sulfuric acid, the former reaction alone takes place. Representing

[2] One of our best teachers of inorganic chemistry was retired in 1917. During the last five years of his teaching he was persuaded to discard the dualistic method of writing equations and found that his students progressed much more rapidly when taught oxidation-reduction reactions on the basis of Johnson's method.

the electron by the conventional symbol ϵ, the reactions are as follows:

(*a*) At the anode: $2H_2O - 4\epsilon = 4H^+ + O_2 \uparrow$

(*b*) At the cathode: $4H^+ + 4\epsilon = 2H_2 \uparrow$

The beginner is taught that the unit electric charge on a gram atom is 96,500 coulombs, or 1 Faraday. He soon learns to read from these equations that the passage of 4 Faradays of electricity through the cell will furnish, in the above case, 22.4 liters of oxygen at the anode and 44.8 liters of hydrogen at the cathode.

(2) **The Formation of Permanganate by Anodic Oxidation of a Manganese Electrode.**—From the fact that oxygen, except in peroxides, has a negative polarity of 2, it is clear that the Mn of MnO_4^- must have a polarity of +7, as Johnson pointed out because the polarity of a radical is always the algebraic sum of the polarities of its constituents. Therefore to change a manganese anode to MnO_4^- it must lose 7 electrons. The reaction usually takes place in a solution of sodium carbonate.

(*a*) At the anode: $Mn^\circ - 7\epsilon + 8CO_3^{--} + 4H_2O = MnO_4^- + 8HCO_3^-$

(*b*) At the cathode: $2H_2O + 2\epsilon = H_2 \uparrow + 2OH^-$

or $2HCO_3^- + 2\epsilon = H_2 \uparrow + 2CO_3^{--}$

(3) **The Oxidation of Tervalent Molybdenum by Potassium Permanganate.**—This reaction usually takes place in the presence of dilute sulfuric acid and is used for the direct determination of molybdenum or for the indirect determination of phosphorus which has been precipitated as ammonium phosphomolybdate. In this reaction the Mo loses three electrons and each atom of Mn in MnO_4^- gains five electrons. The equation can be written at once, as soon as this is known.

$$5Mo^{+++} + 3MnO_4^- + 8H_2O = 5MoO_4^{--} + 3Mn^{++} + 16H^+$$

(4) **The Oxidation of FeS_2.**—Probably there is no single analysis about which more has been written than the determination of sulfur in pyrite. All methods depend upon a preliminary oxidation. In the Fresenius method the sample is fused with potassium nitrate and sodium carbonate. All that the student has to be told is the condition of the iron, the sulfur, and the nitrogen after the oxidation has been accomplished. Let us assume that the products are Fe_2O_3, Na_2SO_4, and KNO_2. It is not necessary to worry about the valence of the Fe and the S in the original FeS_2; it is a neutral molecule. From the rule that the polarity of oxygen is —2, it is clear that the neutral FeS_2 has been converted into ferric iron with a polarity of +3 and sulfate in which the sulfur has a polarity of +6 while the nitrogen has changed from a polarity of +5 to +3. Hence, $2FeS_2$ will react with $15KNO_3$ and when this is established the amount of sodium carbonate is seen by inspection.

$$2FeS_2 + 15KNO_3 + 4Na_2CO_3 = Fe_2O_3 + 15KNO_2 + 4Na_2SO_4 + 4CO_2$$

(5) **The Oxidation of Fe_3P by Nitric Acid.**—Here the neutral Fe_3P has its iron oxidized to the ferric state and its phosphorus oxidized to the quinquevalent state, so that the neutral molecule loses 14 electrons. If the nitric acid is reduced to NO, each atom of nitrogen accepts three electrons and the equation is:

$$3Fe_3P + 14NO_3^- + 41H^+ = 9Fe^{+++} + 3H_3PO_4 + 14NO + 16H_2O$$

The reaction shows that 41 molecules of nitric acid are necessary for 3 molecules of Fe_3P but only 14 molecules of NO_3^- are reduced to NO. As soon as the Fe_3P and NO_3^- are written with the correct numbers and the equation is written out, the $41H^+$ can be obtained by making the number of charges the same on both sides of the equation and also by using enough H^+ to satisfy all of the oxygen atoms.

(6) **The Fusion of Chromite, $FeCr_2O_4$, with Na_2O_2.**—Johnson's rule shows that the original polarity of $[FeCr_2]$ is plus 8. There is some question as to whether Fe_2O_3 and Na_2CrO_4 are formed in the melt or $NaFeO_2$ and Na_2CrO_4. Johnson's rule shows that the polarity of $FeCr_2$ becomes $+15$ in the products and when Na_2O_2 is reduced to NaO_2 it is usually assumed that the polarity of the sodium does not change but that O_2^{--} is changed to $2O^{--}$ in the products. Therefore, the chromite loses seven electrons and the peroxide molecule accepts two and the equation is:

$$2FeCr_2O_4 + 7Na_2O_2 = 2NaFeO_2 + 4Na_2CrO_4 + 2Na_2O$$
$$\text{or } 2FeCr_2O_4 + 7Na_2O_2 = Fe_2O_3 + 4Na_2CrO_4 + 3Na_2O$$

(7) **The Oxidation of Cuprous Thiocyanate by Potassium Iodate.**—This reaction, first described by Jamieson, Levy, and Wells,[3] represents one of the most accurate and most rapid methods for the determination of copper. The copper solution is treated with alkali thiocyanate and sulfurous acid and the precipitate of CuSCN is filtered off. The precipitate is then thrown into a bottle containing hydrochloric acid and is titrated with KIO_3. As long as an excess of precipitate is present, some of the iodate is reduced to free iodine but subsequently this is oxidized to ICl. The final products are, therefore, Cu^{++}, SO_4^{--}, ICl, HCN, and water. In this reaction univalent copper has been oxidized to bivalent copper and the univalent SCN anion has been changed to SO_4^{--}, in which the sulfur has a polarity of $+6$ and in HCN the CN has a negative polarity of -1. The oxidation therefore corresponds to a loss of 7 electrons by the CuSCN. The reduction corresponds to a gain of 4 electrons by the KIO_3 reduced to ICl. The final equation is:

$$4CuSCN + 7IO_3^- + 14H^+ + 7Cl^- = 4Cu^{++} + 4SO_4^{--} + 4HCN + 7ICl + 5H_2O$$

[3] *J. Am. Chem. Soc.*, **30**, 760 (1908).

(8) **The Oxidation of Oxalate by Permanganate.**—This reaction is used for the standardization of permanganate, for the analysis of oxalates and for the indirect determination of various cations such as Ca^{++}, Pb^{++}, Hg^{++}, etc., which form insoluble oxalates. The polarity of C_2 in the $C_2O_4^{--}$ ion is $+6$. This seems, at first sight, to indicate that the valence of C is 3, whereas every organic chemist is certain that the valence of carbon is 4. In considering polarity for oxidation-reduction reactions it is only the valence bonds toward other elements that count. Thus F has a polarity of -1 in hydrofluoric acid, whether the molecule is HF or H_2F_2, and Cu has a polarity of $+1$ in cuprous chloride, whether the formula is CuCl or Cu_2Cl_2. So carbon when it is united with another carbon atom has one of its bonds neutralized and the effective polarity of the C_2 in $C_2O_4^{--}$ cannot be other than $+6$. Therefore, when $2CO_2$ are formed from $C_2O_4^{--}$, there is a loss of two electrons and since MnO_4^- gains 5 electrons to form Mn^{++}, the reaction is:

$$2MnO_4^- + 5C_2O_4^{--} + 16H^+ = 2Mn^{++} + 10CO_2 + 8H_2O$$

(9) **The Oxidation of Ethyl Alcohol to Acetic Acid.**—If this reaction takes place in alkaline solution with permanganate, MnO_2 is the reduction product. In alcohol, CH_3CH_2OH, the oxidation takes place at the second C atom, where H_2 is replaced by O to form $CH_3CO_2^-$. Since the 2H have a total polarity of $+2$, and the O in the molecule has a polarity of -2, the carbon atom obviously loses four electrons. The MnO_4^- accepts 3 electrons so that the equation is:

$$3C_2H_5OH + 4MnO_4^- = 3CH_3CO_2^- + 4MnO_2 + 4H_2O + OH^-$$

Or, if the reaction takes place in acid solution and the MnO_4^- is reduced to Mn^{++} as:

$$5C_2H_5OH + 4MnO_4^- + 12H^+ = 5CH_3CO_2H + 4Mn^{++} + 11H_2O$$

This principle can be applied to every oxidation and reduction of organic compounds. It is particularly well suited for explaining electrolytic oxidations and reductions as will be shown by two examples taken at random.

(10) **The Electrolytic Reduction of Benzophenone.**—When benzophenone is reduced in an electrolytic cell containing sodium acetate and alcohol diluted with one-fifth as much water, benzhydrol is formed with 90% current yield. In this reaction the ketone is changed to a secondary alcohol according to the general scheme R—CO—R $\longrightarrow$ RCHOHR. Originally, the C atom of the ketone group was positive, according to Johnson's rule, to the negative oxygen atom and in the product of reduction it is positive to OH and negative to H so that two electrons have been acquired. The reaction at the cathode is therefore

$$C_6H_5COC_6H_5 + 2\epsilon + 2H_2O = C_6H_5CHOHC_6H_5 + 2OH^-$$

(11) **The Electrolytic Oxidation of Acetate.**—Kolbe showed in 1849 that by the electrolysis of a concentrated solution of potassium acetate, considerable ethane and carbon dioxide were formed at the anode. In the acetate anion, $CH_3CO{\cdot}O^-$, the C bonds that are united to one another serve to neutralize the fourth valence of each carbon atom, possibly by sharing an electron, as Langmuir has suggested. The second C atom therefore has a polarity of +3 and is oxidized to CO_2 with a polarity of +4. The reaction and the anode can be expressed thus:

$$2CH_3CO_2^- + 2\epsilon = C_2H_6 + 2CO_2$$

Summary

The so-called "valence-change," "pole-reaction" and "ion-electron" methods of balancing equations of oxidation-reduction reactions are merely modern versions of a method published by Otis Coe Johnson in 1880. The electron theory of the constitution of matter helps us to understand this method, which is so simple that a beginner can understand it readily and so general in its application that all oxidation-reduction equations can be worked out rapidly in a single step. In balancing these equations, the oxidizer and reducer should first be balanced on the basis of the number of electrons accepted by the oxidizer and the number of electrons given up by the reducer. When this relation is established, it is easy to assign the proper numbers to the formulas of other compounds that may take part in the reaction. The method should be taught to beginners and it is mistaken pedagogy to attempt to teach them any other more difficult method. When beginners have some idea of the ionization theory, as is the case with most high-school pupils of today, they find it easier to work with ions than with whole molecules. To illustrate the application of the method a number of fairly complicated reactions are given, all of which can be worked out quickly in one step in much less time than it takes to tell about them. The writer has been teaching this method for about twenty-five years.

The Indian Oil Industry. The increasing imports of oil-crushing machinery into India show that the oil mill industry is prospering. In Bombay, a new company has been registered for oil-crushing purposes, and will begin operations within a short period with up-to-date machinery. The Tata Oil Mills have been showing continuous losses for some years past, but as the Chairman of the Board explained at the annual general meeting held recently, there are signs of improvement. The company suffered loss during the past year, but this was mainly due to the difficulty of getting rid of the coconut cake and the low prices of cake. Various alterations and additions to the plant are being made, which, when completed, will materially increase the productivity of the mills.—*Chem. Age*, **20**, 97 (Feb. 2, 1929).

THE TEACHING OF QUALITATIVE ANALYSIS IN SECONDARY SCHOOLS*

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Under suitable local conditions a half-year course in qualitative analysis, following a year of general chemistry, can make a distinctive contribution to the science program of the secondary school and can serve to supplement and reënforce the course in general chemistry in the attainment of certain generally recognized objectives.

Some Distinctive Features of Qualitative Analysis

Some of the distinctive features of qualitative analysis may be briefly outlined as follows:

1. It is inherently a laboratory course. In qualitative analysis, to a greater extent than in any other science course commonly offered in the high school, the pupil learns through his own activities.

2. Analytical work demands greater continuity of effort, more sustained attention to details. The pupil soon learns that what he does at one point in his work is significant not only in itself but also in its possible effect upon the work which follows. He must be on the alert all the time and follow things through to the finish if he is to be successful.

3. Another distinctive feature of qualitative analysis is its automatic emphasis upon the value of system and accuracy in procedure. Slipshod work brings its own inevitable penalties, systematic and careful work reaps its sure reward in the satisfaction which comes from the correct solution of a concrete problem.

4. In qualitative analysis the pupil is independent in his laboratory work to a greater degree than is possible in most science courses. Each student is working on a problem of his own and must stand or fall on his own efforts. In the nature of things he must do his own work and draw his own conclusions.

5. An experience of some twelve years in the teaching of qualitative analysis to high-school students has convinced the writer that this type of work catches and holds the interest of the student in a distinctive way. Every "unknown" is a challenge to his ability to follow up clues, gather evidence and draw conclusions, as does the sleuth in the detective story. In how many courses must teachers meet requests from pupils for extra working time in the laboratory outside of regular hours? To the teacher of qualitative analysis this is a common experience.

* Contribution to the Symposium on The Teaching of Analytical Chemistry, held by the Division of Chemical Education, at the 75th Meeting of the A. C. S., April 17–18, 1928, at St. Louis, Missouri. See THIS JOURNAL, **5**, 937–89 (Aug., 1928).

Objectives of High-School Chemistry and How Qualitative Analysis May Help Attain Them

What are the objectives of high-school chemistry for the attainment of which the study of qualitative analysis may supplement and reënforce the course in general chemistry? Of the objectives listed by the Committee on Chemical Education of the American Chemical Society, the following are selected in this connection:

1. *To show the service of chemistry to the home, to health, to medicine, to agriculture, to industry—in a word, to show the service of chemistry to the nation.* Probably most of us who teach qualitative analysis would have to plead lack of time as our excuse for not doing as much as could be done along the line of this objective. There is a wealth of illustrative material with which to show the valuable services which are daily being rendered through practical applications of qualitative and quantitative analysis.

2. *To train the student in keen observation and exact reasoning.* Observation is motivated in analytical work. The extent to which the student is brought to exercise his powers of reasoning depends largely upon the way in which the course is conducted.

3. *To build upon earlier science courses and knit them together.* In an elementary course this applies chiefly to building upon the course in general chemistry, particularly with respect to such topics as solutions, reactions of acids, bases, and salts, oxidation and reduction, ionic theory, and methods of separation based on differences of solubility.

4. *To help pupils to find themselves—to discover whether they have an aptitude for further study in chemistry or applied science.* Of the objectives cited by Dr. S. R. Powers in a list prepared by him a few years ago, qualitative analysis may claim to help toward the attainment of the following:

> 1. To contribute such specific ideals, habits, and concepts as those of accuracy, achievement, persistency, open-mindedness, honesty, cause and effect, which are essential to the study of science.
> 2. To develop system, order, neatness, and possibly other attributes to the end that they may function in ordinary life.
> 3. To give such training as will result in increasing respect for the work of recognized experts.

These objectives may well be among those set up for qualitative analysis in the secondary school.

In an article on "The Cultural Value of Qualitative Analysis" [THIS JOURNAL, **4**, 355 (March, 1927)] Edgar J. Witzemann states:

> What is wanted is a type of training of this sort that is available for large numbers of pupils at an early stage of their mental maturation. Something is wanted in which it is possible for the pupil to test and retest in his own way and to his own satisfaction the

utility and logic of the method that he is being taught. Something in which his teacher, if he wishes, can dissociate himself temporarily from his position of superiority and approach the problem in the same spirit as the pupil. The material should be well within the scope of the powers of the pupil so that he need not rely too much upon authority..... For such purposes as these in training in the scientific method, it is the writer's opinion that qualitative analysis offers advantages over all other subjects in the curriculum, other things being equal.

Effect of High-School Qualitative Analysis upon College Chemistry

It would be of interest to know what effect, if any, the study of qualitative analysis in high school may have upon the student's success in beginning college chemistry. During the years 1920–27, two hundred

TABLE I

	Chemistry studied in the high school		
	None	General chem.	Gen. chem. + ½ yr. of qual. anal.
I. Enrolment in college chemistry			
Number enrolled in university	41	85	115
Number taking college chemistry	12	41	85
Per cent taking college chemistry	29.3%	48.2%	73.9%
II. Average rating in college chemistry			
Group *A*	(2) 78.0	(12) 80.3	(42) 85.7
Group *B*	(8) 55.0	(12) 71.7	(30) 74.2
Group *C*	(2) 55.5	(17) 61.5	(13) 68.0
All groups, mean	(12) 58.9	(41) 70.0	(85) 78.9
All groups, median	63.5	70.0	80.0
III. Rated 80 to 100 in college chemistry			
Group *A*		7/12 = 58.3%	34/42 = 80.9%
Group *B*		1/12 = 8.3%	9/30 = 30.0%
Group *C*		1/17 = 5.9%	1/13 = 7.7%
All groups		9/41 = 21.9%	44/85 = 51.8%
IV. Failures in college chemistry			
Group *A*	None	None	None
Group *B*	3/8 = 37.5%	1/12 = 8.3%	1/30 = 3.3%
Group *C*	1/2 = 50.0%	4/17 = 23.5%	2/13 = 15.4%
All groups	4/12 = 33.3%	5/41 = 12.2%	3/85 = 3.5%
V. Comparison of students who were rated 80 to 100 in general chemistry in high school			
Number		22	72
Average rating in general chemistry in high school		86.7	87.8
Average rating in college chemistry		74.7	80.0
VI. Comparison of students equated as to I. Q.			
Number		18	18
Average I. Q.		116	116
Average rating in college chemistry		80.2	87.4

forty-one boys who graduated from Grover Cleveland High School, St. Louis, entered Washington University. One hundred thirty-eight of these boys enrolled in chemistry upon entering the University. Since intelligence quotients were on record for only a part of these students, it was not possible to make an extensive comparison on this basis. For purposes of this study, they were classified in groups *A*, *B*, and *C*, according to whether they were in the upper, middle, or lower third of their respective high-school graduating classes on the basis of their scholarship averages for a four years' course. Pupils showing similar aptitude for chemistry, as judged by their rating of 80 to 100 in general chemistry in the high school, are compared in part V of the tabulation below. Data concerning eighteen pairs of students equated as to intelligence quotients are given in part VI. Throughout the tabulation the rating in college chemistry is taken from reports of the first semester's work.

In part I of the tabulation the figures indicate that the students' interest in chemistry which led them to elect qualitative analysis in the high school was well sustained through their experiences in this course, 74% of these boys having enrolled in chemistry in the university as compared with 48% of those who had studied only general chemistry in the high school.

In part II of the tabulation the differences which appear in the average ratings in the first semester of college chemistry are in favor of those who had qualitative analysis in the high school. Data in parts III and IV suggest that chances for doing good or excellent work (80–100) in beginning college chemistry are better and chances for failure are less for those students who have had qualitative analysis in the high school in addition to the usual course in general chemistry.

Current Practices in High-School Qualitative Analysis

In an attempt to obtain some information in regard to current practices in high schools where qualitative analysis is taught, a questionnaire was sent to sixty-seven high schools scattered throughout the country. Prof. J. O. Frank, Wisconsin State Teachers' College, kindly furnished a list of over fifty schools in which it was thought that such a course was in operation. The forty-four replies are summarized below:

1. *Is qualitative analysis taught in your school?* Yes, 28; no, 16.
2. *If so, how long has this course been given?* Less than 3 yrs., 3; 3 to 9 yrs., 12; 10 or more yrs., 5; uncertain, 8.
3. *Do you intend to continue the course?* Yes, 21; if possible, 5.

May the following outcomes be justly claimed for qualitative analysis for most of the pupils taking it?

4. *More complete attainment of generally recognized aims of high-school chemistry than can be realized through general chemistry alone?* Yes, 25; no reply, 3.
5. *Greater interest in chemistry?* Yes, 25; no reply, 3.
6. *Greater interest in science in general?* Yes, 16; no, 2; doubtful, 7.

7. *Greater faith in the methods of chemistry?* Yes, 25.

8. *Desire to study more chemistry?* Yes, 24; possibly, 1.

9. (*a*) *Is qualitative analysis given as a distinctive half-year course?* Yes, 14.

(*b*) *Is qualitative analysis given as part of the second semester's work in general chemistry?* Yes, 14. *If so, for how many weeks?* 10 to 16 wks., 6; 5 to 8 wks., 4; 4 wks. or less, 4.

10. *Length of laboratory periods in qualitative analysis?* Average, 80 min.; most common (12 out of 28), 80 to 90 min. *How many of these periods per week?* Average, 3.5.

11. *Minimum length of lab. period which you consider satisfactory for qualitative analysis?* Average, 89 min.; 14 out of 28 say 90 min.

12. *Length of period for lecture, recitation, or discussion?* Average, 51 min.; 40 to 50 min., 16; 60 min., 7; 70 min., 2. *How many of these periods per week?* Average, 2+.

13. *How many weeks are devoted to analysis of unknown solutions (detection of cations only)?* Average 11 for half-year course.

14. *How many weeks are devoted to analysis of unknown solids (detection of cations and anions)?* Average, 7 for half-year course.

15. *Indicate what cations are omitted from or added to the following list, in your course:* Pb, Ag, Hg^{+}, Hg^{++}, Cu, Bi, Cd, Sb, As, Sn, Co, Ni, Fe, Cr, Al, Zn, Mn, Ba, Sr, Ca, Mg, Na, K, NH_4. Replies show that prevailing practice for half-year course is to give the cations listed above. One adds Li, 1 adds Pt and Au, 1 omits Na, K, NH_4, 2 omit Sb, As, Sn.

16. *Check those, if any, of the following anions which are omitted in your course: arsenate, arsenite, borate, cyanide, ferricyanide, ferrocyanide, fluoride, nitrite, oxalate, silicate, sulfocyanate, tartrate, thiosulfate.* A majority of all schools reporting omit arsenate, arsenite, cyanide, fluoride, sulfocyanate, thiosulfate. Given in the course: oxalate, 22; tartrate, 22; borate, 21; silicate, 20.

17. *Of the following topics, check those which you stress in recitation periods.* (*a*) *Methods used in the scheme of analysis.* (*b*) *Reasons for the various steps in analytical procedure.* (*c*) *Equation writing.* (*d*) *Law of mass action.* (*e*) *Ionic theory.* (*f*) *Common ion effect.* (*g*) *Solubility product.* Replies show that a majority of all schools reporting and nearly all schools giving a half-year course emphasize topics (*a*), (*b*), (*c*), (*e*).

Professor Frank believes in the plan of giving qualitative analysis as a part of the second semester's work in general chemistry in the high school. In his book on "Teaching First-Year Chemistry" he says:

> There is no other course in the realm of science which can arouse the interest of the student and enforce his respect like qualitative analysis well given. The giving of qualitative analysis as the second semester's work will do away with the monotonous routine which most elementary courses settle into during the second semester..... Instead it will make the work of the second semester even more interesting and alive than the work of the first semester.

The writer has never attempted to teach qualitative analysis as a part of the second semester's work and is not qualified to discuss the advantages and disadvantages of this arrangement. On general grounds it seems questionable whether the important topics in general chemistry which must necessarily fall into the second semester will leave sufficient time for a

worthwhile course in qualitative analysis. However, the reports from teachers who are trying this plan indicate that they find it satisfactory and expect to continue it. Apparently these teachers find it feasible to have their classes carry out some work in qualitative analysis in connection with the study of the metals, making such variations from the usual order of the metals as the situation demands. The replies to the questionnaire did not bring out adequate information as to just how much actually is accomplished in analytical work under this method.

A full half-year is not too long for a thorough-going elementary course in qualitative analysis. Time must be allowed for discussions to clarify the student's understanding of the reasons for the various steps in the scheme of analysis which he is using and for the precautions to be taken at various points. Unless some check-up is maintained on this matter, both in recitation and in the laboratory, the student is likely to fall into a rut of routine, a mere following of directions—a kind of mechanical performance unworthy of the name of analytical work.

There will not be time for more than the fundamentals of the theoretical background and probably not much of this could be successfully undertaken with high-school students even if time were available. The writer's practice in regard to item no. 17 of the questionnaire is in line with that of the majority who replied.

Some Suggestions

In deciding upon the best use of available time, the teacher of qualitative analysis has to consider, among other things, the following questions:

1. Are preliminary experiments with salts of the individual metals of sufficient value to justify the time required for them? The writer agrees with those who maintain that preliminary experiments preceding each group of cations should be limited to reactions which will actually be used later in the scheme of analysis. These experiments should be motivated by making the student realize their usefulness: if he gives proper attention to the preliminary reactions, noting the color and form of precipitates and so forth, he may be more than repaid later by time saved in actual analyses through recognition of the absence of certain metals and consequent shortening of the procedure.

2. Should the student go through the analysis of a known solution in a given group before attempting an "unknown" of that group? This practice gives the student an opportunity to find out whether he really understands the directions so that he can translate printed words into intelligent action. It also enables him to find out where difficulties are likely to be met and how to surmount them; where mistakes are likely to occur and how to avoid them.

3. Should a time limit be set for each analysis? Some experienced teachers have reported using this scheme to advantage.

Most texts require the exercise of the teacher's judgment as to selection and adaptation of the material to be used. Straightforward, clear-cut directions for procedure are needed, and if there are swampy spots in an otherwise good book the teacher may do well to bridge these over with directions prepared by himself and adapted to the course as he wishes to give it.

It seems unnecessary to emphasize the importance of the teacher's skill and resourcefulness as determining factors in the success of qualitative analysis as a secondary school subject. A group of wide-awake high-school students out on the trail of the "unknown" under an enthusiastic and resourceful guide can make any chemical laboratory a place of lively activity and wholesome comradeship, where joy in the quest abounds!

DISCUSSION

JAMES E. WILDISH, JUNIOR COLLEGE OF KANSAS CITY, MISSOURI

I suppose that it would go without saying that qualitative analysis is given to teach pupils to analyze. Whether some is given during the latter part of the high-school course, or the year following, it serves another very important purpose, namely, to drill pupils on the fundamentals of elementary inorganic chemistry. To approve such a course as Mr. Kelsey suggests is to sanction a method, perhaps the best method, of impressing these fundamental facts, and at the same time to teach the students to do simple analyses.

In the attempt to make chemistry practical, I am afraid that the fundamentals are not receiving the attention that they should have. In short, we are "applying" a little too freely without having anything to apply. There are a few fundamental concepts that should stand out and clearly differentiate chemistry from the other courses. It is true that the large percentage of the students are not going on to college, but why should they not have definite, accurate ideas concerning these fundamental concepts, which will better enable them to appreciate chemistry in everyday life and to read more intelligently scientific literature, even in newspapers? The amount of scientific literature for the lay reader is rapidly on the increase. This means that the beginning course should give *some* chemistry, not *something about* chemistry. For those continuing with some type of scientific work, these fundamentals, well ground in, will well serve as a foundation for the building of future courses. I see no real reason for differentiating between those who are, and those who are not going on to

college as far as these fundamentals are concerned. Well-chosen, accurate knowledge, in any field, is the most practical.

It really makes little difference just what succeeds this fundamental work. Whatever it is, it should be used largely to drill into the pupils what they have learned during the early part of their course. In presenting these fundamentals, illustrations from the pupil's environment should be freely used, rather than illustrations far removed from their experiences. If it is desirable to put girls into classes by themselves and give them work on sugars, baking powders and so forth, well and good. If it is desirable to put boys, or boys and girls, into another class and make the work such that it might be called applied or practical chemistry, well and good. My contention is that no matter what the course is called, these fundamentals can be and should be kept in the foreground and applications made of them every time opportunity presents itself. Whether a girl has heated five grams of sugar in a test tube or a boy has precipitated copper with hydrogen sulfide, I think that we should not be satisfied unless they can answer such questions as, how many grams of carbon can be obtained from five grams of sugar? What is the chemical reaction involved? What is the percentage composition of sugar? What is the weight of water given off? What weight of copper sulfide can be obtained from a given weight of copper chloride? What volume of hydrogen sulfide will be required, under given conditions, to precipitate the copper? What is the chemical reaction involved? and so forth. Questions such as these show clearly that you can continually drill on the fundamental ideas regardless of what the pupils are doing in the laboratory. These weight and volume relationships, along with some work on solutions, ionization and so forth, can be emphasized all along the line, and unless they are emphasized, the student has not had chemistry, and in the last analysis, the course is not practical.

Certainly one of the best ways of continually reviewing pupils on these fundamental concepts is to give them some work in simple qualitative analysis. This is true even if some of it is given during the latter part of their high-school course. This is better, I think, than giving much of the descriptive matter we are now giving, especially after the pupil has studied two or three typical metals. Even some assigned readings, with discussions, of the spirit and service of chemistry would be preferable to much of this material. I would strongly recommend this. As you reduce a great symphony to the tickling of a cat's intestine with a horse hair, and lose the symphony, so you can reduce chemistry to cold bare facts, equations, and so forth, and not get as much as a glimpse of its spirit, let alone its service to humanity.

Mr. Kelsey goes a little further and gives qualitative analysis the half year following the year in high school. If it is well done there is no doubt

that it would reënforce the work done the first year. For the student intending to pursue work of a scientific nature, it would be very valuable, especially if there is much discussion with the fundamentals kept continually in mind. If this is done, as Mr. Kelsey suggests, the course will have served its purpose.

I wish to emphasize the "well done" for on this depends the value of this or any other course in qualitative analysis. There are few courses where a pupil can kill more time than in a "cook book" course in qualitative analysis. They can acquire habits, which from the standpoint of technic, are actually bad. It would seem best not to try to give the course except in high schools where the instructor is fully competent and the equipment adequate.

In general, it is better that students take physics before they take chemistry. This would mean in the ordinary four-year high school that the student would take physics during the junior year and chemistry during the senior year. It would be hard to follow this sequence unless the physics is pushed back to the sophomore year, which perhaps is not advisable. The value received from this course in qualitative analysis, I believe, would more than offset the advantage gained in trying to follow the above sequence.

Some are complaining of the overcrowded high-school curriculum. If the teacher has the time and the equipment, this course could be offered as an elective. It should be an elective any way, as it would be undesirable to try to require it of all pupils. Those who have done well in their first year's work and who are going to pursue further work of a scientific nature should take it.

Mr. Kelsey leaves nothing to be said concerning the breadth and depth of the work for pupils of high-school age. This, in general, should after all be pretty much of a review of the fundamental principles referred to above. Besides the new material that has to be given concerning the methods of analysis, there is ample room for plenty of drill on nearly all, if not all, of the fundamental principles of elementary inorganic chemistry.

His contention for straightforward directions for procedure are to the point. If these are not supplemented by discussions as he suggests, the course is liable to become "cook bookey" regardless of these directions. The type forms, especially, should be kept constantly before the pupil. Most of the reactions involved are metathetical. Such general reactions as neutralization, action of nitric acid on metals and sulfides, examples of ammoniation, action of aqua regia, amphoteric reactions, hydrolysis, oxidation-reduction reactions, and so forth. The pupil should be led to see that while a great many reactions are involved, they after all fall under a comparatively few general types. These may be well brought out

in the discussions as suggested by Mr. Kelsey and I consider them one of the most important phases of the course.

There is nothing to add to the discussion of the minimum apparatus and the minimum time to be spent on the work. Unless a high school can meet these conditions, it should not try to give this course. In general, there is little to say in opposition to such a course if given as Mr. Kelsey suggests. His discussion of the work done by the high-school students of St. Louis shows that the work is well done.

DISCUSSION

ROBERT COLLIER, JR., SOUTH HIGH SCHOOL, DENVER, COLORADO

Mr. Chairman: I wish to disagree with the previous speaker, Mr. Wildish, in the matter of drill on essentials, such as equations, laws, and formulas. I believe that nothing is more deadly to the interest of boys and girls in high school than continued drill of this nature.

In our high school approximately 20% of the students graduating continue on to college. Of that number, one-half will have had chemistry in high school. Thus, less than 10% will ever have an opportunity to apply the laws and theories of chemistry directly, while 90% will possibly never solve a chemical problem or write an equation again. Should we teach in high school for the 10% who will use chemistry in college and disregard the 90% who will never have chemistry again?

In the matter of the qualitative analysis, at South High, in Denver we teach approximately six weeks of elementary analysis, taking up 22 simple metals and 5 acids. In this course we attempt to review our previous work and give the student an idea of what may be obtained by using chemistry as a tool. I find that nothing awakens more interest or produces better results than does this short work in qualitative analysis.

I would like very much to hear expressions from other schools in this regard.

Production of Oil from Australian Coal. German and Australian interests (states *The Daily Telegraph*) are coöperating in a large scheme for the extraction of oil and other by-products from Australian coal. With this object in view some 32,000 acres have been acquired at Ellalong, in the West Maitland district of the northern coal fields of New South Wales. It is reported that £3,000,000 will be spent on the enterprise, which will employ 1500 Australian workmen. A plant which has been found successful in Germany will probably be installed, German experts being introduced to instruct the Australian staff. Activities are proceeding in other directions in Australia with the same object. Imperial Chemical Industries are much impressed by the possibilities and are installing an experimental plant to test the treatment of brown coal in Victoria, and other large concerns are proceeding in the same direction.—*Chem. Age*, **20**, 19 (Jan. 5, 1929).

FOSTERING SCIENCE CLUBS IN THE HIGH SCHOOL[1]

LOUIS A. ASTELL, WEST CHICAGO COMMUNITY HIGH SCHOOL, WEST CHICAGO, ILLINOIS

Two statements of apparent significance represent the keynote of this treatment on the fostering of science clubs in the high school. The first, by Professor Dewey, is that "the future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind;" and the second by Wiggam is to the effect that the spirit and methods of science are worth vastly more than the discoveries of science, since it is through this spirit and by these methods that the future discoveries will be made.[2] Something of the magnitude of these statements comes to us when we consider the opinion of Edison who, with more than 1450 patents in his own name, says that in the next forty years there will be more inventions and discoveries than in the past four hundred years.

The enormity of these figures, even though they constitute a prediction, should give teachers of science a still greater vision of the importance of their task. Out of this extended conception there can be, there must be, a united and more painstaking effort to adjust the pupil to that enormity which will engulf him in his own lifetime. As long, then, as extra-curricular activities are accorded a place in our educational system, the major or academic subjects, including science, are entitled to the advantages of clubs or other supplementary organizations designed to inculcate in the student the greatest possible measure of training and leadership. Through science clubs there may be established a further regard for truth, a greater accuracy of observation, a more perfect fidelity of report, a much-needed improvement in the humanizing spirit, a maximum independence of character, and an added respect for law and order. In short, such clubs can give the student a more thorough conception of the spirit and methods of science as applied to the accrued results of science.

That clubs for the academic subjects were largely deserted with the advent of the commercializing influence of athletics in the school and the increasingly attractive phases of life beyond the school is no reason why such clubs should continue to remain deserted. In making this statement I do not wish to decry the merits of athletics as they contribute to the individual's mental and moral supremacy. The fact remains, however, that unless the physical does contribute to the mental and moral aspects, our cause becomes dangerously parallel to that of nations founded on physical force.

[1] Presented before the Chemistry Section of the Illinois High-School Conference, at Urbana, Nov. 23, 1928.

[2] A. E. Wiggam, "The Religion of the Scientist," *World's Work*, **50**, No. 4 (Aug., 1925).

From quite another angle, it is time that we, as science teachers, were doing the constructive things within our power to prevent the origin of further legal barriers to scientific progress. Science clubs can contribute a sympathy for, and an understanding of, science with its manifold benefits for civilization. What group, other than science teachers, is more responsible for the development of this sympathy and this understanding of science? That we have failed to maintain a confidence in science to any extent implies that our emphasis has been misplaced to that extent. Science clubs do have a place, an increasingly important place, in the high-school curriculum as organized at present.

But to establish the validity of science clubs is merely the initial step in establishing clubs. The instructors who sponsor these clubs must be given consideration. I say this out of the bonds of sympathy, as a science teacher who has enjoyed some of the experience that comes from the range of science positions as they occur over the state. I know that the average science teacher is busy with a multitude of details which arise in consequence of conducting simultaneously several courses in science. I know how natural is the tendency to feel that we have given all we should give or all we are paid to give. I know, too, with confirmations from the very recent past, the joy that comes from giving enough to hold students through the strong bonds of interest that develop when these students are given responsibilities and opportunities beyond the limits of their expectations. The immediate results are reconverted into an increased classroom interest, which is a primary objective in the mind of every classroom instructor. Added investments of time are not lost.

All this leads to a logical question. What are the things a science club can do? The question has come to me often enough to warrant an answer in the form of ten important principles from my own experience in such club work.

1. It can offer an endless variety of closed meetings for the membership, with emphasis on student participation. Demonstrations, talks accompanying or contributing to the use of slides and film-slides and films, plays, stunts, field trips, and informal parties are all important activities which will command student attention and interest so necessary to the success of a club.

2. The sponsorship of one or more scientific lectures, annually, for the school and the community can be a complete justification for the existence of any club.

3. The entertainment of clubs and civic organizations by means of special programs is a powerful method of cementing relationships between the school and the community. The practical aspects of increased community loyalty for the administration and the cause of education, together with a further appreciation of science, are the logical derivatives.

4. Through the organized effort of such club membership the club may sponsor benefit programs to purchase for school and club use auxiliary equipment of scientific nature, such as delineascopes, stereopticons, and projectors of the various types. Educational research is developing the importance of such equipment for visual aids. This is borne out by the fact that every accredited high school in the state of Ohio must have a moving picture machine or a stereopticon. Schools frequently are not able to purchase such equipment directly. What more fitting tribute, then, can a science club make to science than to purchase a product of science designed for the advancement of education? The tax-payer, the parent, and the student, each from a different and worthwhile angle, will be quick to appreciate what is being done if such projects are properly handled.

The club for which I am now acting as sponsor, very recently traded an old moving picture machine in on a new one of the more modern type for auditorium and classroom use and met the very large balance due by means of the proceeds of a single benefit program. This achievement was of added significance due to the weather conditions which prevailed throughout the day and evening of the program. Great as was the financial aspect in this case—for the club netted a greater profit than that obtained from any other single evening program in the history of the school—this profit was as nothing compared with the training in detailed and organized leadership of the 110 members of the organization, together with the development of a coöperative spirit on the part of the civic organizations and the community as a whole. The members were used in the presentation of three preliminary programs to the assembly and to the various civic bodies, then used in a closely knitted sales force of the entire membership. Each member had a sales quota. Teamwork was emphasized by making it obligatory for those who had completed their quota to help some other member complete his quota before entering into the competition for the greatest number of sales.

5. Affiliations with such organizations as the Illinois State Academy of Science,[3] the Izaak Walton League of America,[4] and the National Association of Audubon Societies,[5] followed by participation in, or functioning through, these worthwhile organizations, represents another valuable opportunity. When student delegates are sent to meetings of the state academies of science and to similar meetings in something of the numbers and with something of the regularity enjoyed by these same students in the

[3] Doctor Lyell J. Thomas, Secretary, University of Illinois, Natural History Building, Urbana, Illinois.

[4] Harry C. Goodwin, Chairman of the Executive Committee, Izaak Walton League of America, Rochester, New York.

[5] National Association of Audubon Societies, 1974 Broadway, New York City.

various phases of state athletics, there will be a tremendously increased interest in science.

6. For individual members there should be pins and credentials of membership in the form of neat cards bearing, among other things, evidence of the affiliations of the organization. This form for the card may serve to indicate the possibilities of such a device: If the pin and the card are

EDISONIAN SCIENCE CLUB

Affiliated with the Illinois State Academy of Science

CREDENTIALS OF

.....Number.....

a.....in the West Chicago Community High School

as to.....membership

from.....192.... to.....192....

"It may well be that men of science, not kings or warriors or even statesmen, are to be the heroes of the future."

.....Secretary

Signature of Member

not standardized for all clubs affiliated with the academy of this state, there might well be a certificate issued by the academy to the separate clubs which would set forth the facts of affiliation.

7. All the members in good standing at the time of departure from the school system should be given the status of permanent honorary membership and should receive credential cards on this basis. There should be an annual program for these members as another and a most effective means of rendering service to the cause of education through maintenance of ties so frequently neglected in educational work as practiced.

8. The constitution should be thoroughly developed and thoroughly utilized in the meetings, in order that the membership may continue to function even in the event that the sponsor's successor takes no active interest in the work. Continuous perpetuation is highly desirable. Much can be done toward safeguarding it under this plan.

9. The club can carry out the principles of vision as applied to adjustments for the student and the community, in full recognition of the fact that unless scientific activity contributes largely to a general vision and to a common good it does not deserve the name of science.

10. All the general principles and the psychology which contribute toward the success of any club, either local or national, may be utilized by the science club to advantage. Included in these principles and in this psychology is the initial organization of the club toward the end of the school year. Such a plan gives time for a proper mental set on

the part of the members during vacation months. Large clubs, with or without sectional divisions, offer outstanding possibilities when functioning as a whole. In this connection I may say that, while clubs of less than fifty members are the general rule, my experience has been limited to clubs of more than that number. The nature of the activities selected depends largely on the number of members. The only important consideration is to select activities such as will make opportunities for all the members to feel that they are of consequence to the welfare of the club. Bulletin board work in the form of daily memoranda and of membership thermometers has never failed me in placing the total enrolment where I thought it should be.

These characteristics and objectives of science clubs are not the only worthwhile ones which can be, or are being, developed. The "Modern Alchemists" of Bloomington (Illinois) High School, with a membership limited to thirty-five and under the sponsorship of Mr. H. W. Garnett, has developed a science week for the school during which industrial and student exhibits, posters, and demonstrations attract the attention and interest of students generally. The student exhibits are developed from the collections made on field trips. For these trips business men and interested parents furnish the cars. The club has numbered among its trips one to the starch works of Decatur and another to the cement works at La Salle.

The chemistry club of the Rockford Senior High School, which is under the sponsorship of the chairman[6] of this session and is affiliated with the Illinois State Academy of Science, conducts assembly programs for the junior and senior high schools, gives a formal banquet and two picnics annually, entertains the parents, and gives prizes for commercial products as duplicated by the students.

There is a great variety of possibilities for science clubs everywhere. These clubs are worth developing from many points of view, but the chief consideration is that of developing leadership in the student and an increased interest and appreciation for the spirit and methods of science on the part of the students and the community. That we, as teachers, must include these activities in our program is further indicated through Professor Judd's words: "The scientific attitude of mind is by no means a simple attitude, and it is not one which is readily assumed by the immature thinker."[7] We must develop these clubs because the need for this scientific attitude is increasing rather than decreasing, and because the club offers certain dynamic opportunities for the development of clear vision and sane

[6] Miss S. Aleta McEvoy, Chemistry Department, Rockford Senior High School, Rockford, Illinois.

[7] Professor Charles H. Judd, "The Psychology of High School Subjects," Ginn & Co., p. 304, 1915.

attitudes toward the problems of today, all of which means progress generally as well as scientifically.

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[8] Single reprint copy from author at 10 cents.

[9] Single reprint copy from author at 15 cents.

The victory of success is half won when one gains the habit of work.—*Sarah A. Bolton*

PROGRESS CHARTS IN ELEMENTARY CHEMISTRY

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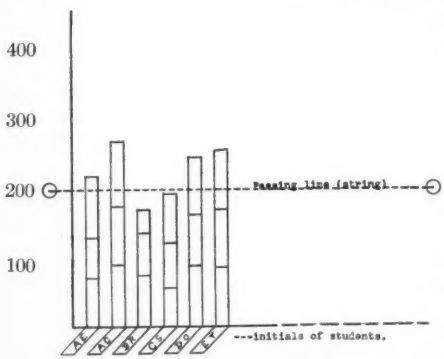
Several years ago, the author happened to be reading a book on statistical charts and graphs. In one chapter of this book was a description of various progress charts that were used in factories in order to visualize the progress of material throughout the manufacturing processes. Immediately it occurred to the author that an analogous chart would be desirable in several ways in elementary chemistry. Such a chart that would show the progress of a student through elementary chemistry should be simple, easily constructed, and practically continuous; it should also show the standing of the student relative to the rest of the class and indicate clearly at all times what students are not passing the course. These are some of the characteristics to be desired in such a chart.

If the progress chart is to be simple, easily interpreted, and constructed, one is limited immediately to the simplest forms of charts. Probably the simplest, and the most easily constructed and interpreted, is some form of the bar chart, either the vertical or the horizontal type. The horizontal was the first tried by the author but it was discarded later in favor of the vertical bar chart. The latter was found better visually on account of the fact that grades are thought of as going up or down rather than horizontally.

By having a row of vertical bars in the chart, each student having an individual bar which represents his standing, a simple means of showing the relative standing of each member of the class is available. The desirable feature of making the progress chart more or less continuous puzzled the author for some time. The best method that suggested itself was to make it cumulative; that is, one set of bars is added on to the previous set. In the illustration, each vertical bar appears like an irregular bamboo pole, each segment having been derived from some examination or test grade, and the relative length of the segment represents a relative grade made by the student. Take the first vertical bar as an example. The student has made the grades of 75, 60, and 95 on three examinations. Therefore, the first segment has a relative length of 75 units (arbitrary units) the second segment a length of 60 units, and the third segment



TYPICAL PROGRESS CHART

a length of 95 units. By using coördinate paper, the segmented, vertical bars are constructed easily, quickly, and accurately. As a second example, consider the vertical bar, the first to the right of the one just considered, a bar which represents the cumulative grades of another student. This student made grades of 95, 90, and 100. The relative standing of the two students is very evident at any time to all concerned, including the teacher. The cumulative feature eliminates the necessity of adding the grades and getting the new average after each examination.

One desirable feature not yet incorporated in the chart would be a means of indicating clearly and continuously the passing line. This can be accomplished easily in several ways but the most successful in the author's experience is to stretch a string horizontally between two thumb tacks across the chart and call this the "passing line." If 70 is to be considered as the passing percentage on the first examination on the chart, then the string is stretched horizontally 70 units above the base line. When the second examination grades are put on the chart, the string is raised 70 more units at the same time, making a total of 140 units, which is the height of the new "passing line." Thus, not only is the student's bar cumulative but so is the height of the "passing line." As the examination grades are recorded on the chart, the vertical bar of a student never drops but the "passing line" (string) rises.

As to means of designating the bars to the respective students, all classes in the author's experience have voted to use the initials of the student at the lower end of each bar (as shown in the illustration). This lends a touch of privacy to the chart. Other systems, such as code numbers, could of course be used if it seemed desirable.

The author has used the above progress chart in his classes in elementary chemistry for several years with enough success, in the author's opinion, to warrant further use. When this chart is used, the student can see with his own eyes at any time his relative standing with the rest of the class, whether he is passing or not, and just how he is progressing in the course. It is the experience of the author that this chart is most useful and valuable in dealing with two classes of students. One is the excellent class which so often does not work proportionately as much as it should. The progress chart stimulates this class of excellent students to keen competition in order to see who is to be the leader. And the spirit often runs high. The other class of students that the chart helps especially is that which hovers around the passing line. In many cases, the chart is an incentive to that class to get down and "dig" enough to pass the course. Apparently, the middle class is affected very little by the chart.

For fear some reader of this article might conclude that this system is proposed as a panacea for all teaching ills in elementary chemistry, the author wishes to state that the chart, too, has its disadvantages. One is that some-

times a student begins to think that the grade is the main object in the course. But, then, that sometimes happens even when the progress chart is not used.

Undoubtedly, improvements can be made on this progress chart and probably a better one devised. Any such improvements, criticisms, or report of results by any one giving the chart a trial, will be welcomed by the author.

Proposed Celebration of the Centenary of Faraday's Electrical Discoveries. On August 28, 1831, Faraday made his first successful experiment on electromagnetic induction. This was the most important of the series of striking discoveries on which modern electrical science and industry are so largely based. Faraday established many other connections between the forces of nature, as, for example, between electrical action and chemical action, between magnetism and light. He made important researches on a number of other physical and chemical questions, such as the relations of the properties of glass to its composition, the regelation of ice and its effects on glacier motion, the nature of the compound now called benzene, the colors and properties of colloidal solutions, diamagnetism and magnecrystallic action, and so on. His work, more than that of any other man, made possible the extraordinary advances of modern physics. His influence on philosophical thought has been immense. The whole of the electrical engineering industry, as concerned in the transmission of power, heat and light, in the conveyance of intelligence by telegraph, telephone, marine cable and wireless, in the chemical applications of electricity and in many other activities, owes to Faraday the revelation and explanation of the principles which make its work possible.

The managers of the Royal Institution have for some time purposed to invite the friends of the Institution to join with them in celebrating the centenary of Faraday's greatest and most striking discovery. They have recently received intimations from some of the great electrical associations that they also would like to take part in such an event.

It seems probable that a very large number of important bodies, some concerned with pure, others with applied science, may be interested in these proposals. It seems probable also that the event may provide a unique and most favorable opportunity for a review of the great contributions which British workers have made to the scientific and industrial advances of the past century. It is certain that such a review might be made a source of inspiration and encouragement to the nation.

By a fortunate coincidence the Centenary of the British Association also falls in 1931, and the meeting for that year will probably be held in London. Certain important conferences on electrical matters will also be held in London in the same year.

In order to bring together all these tendencies and opportunities, the managers of the Royal Institution held a meeting at the Institution February 5th, when the proposals for the centenary celebrations were discussed and preparations set on foot.—*Chem. Age*, **20**, 93–4 (Feb. 2, 1929).

Revised German Atomic Weights. The German Atomic Weight Commission, consisting of Professors O. Hönigschmidt, M. Bodenstein, O. Hahn, and R. J. Meyer, states in its report for the year 1928 that they have adopted the following changes in atomic weight: barium 137.36 (hitherto 137.37); cerium, 140.13 (hitherto 140.2); erbium, 167.64 (hitherto 167.7); neon, 20.18 (hitherto 20.2); and uranium, 238.14 (hitherto 238.18).—*Chem. Age*, **20**, 90 (Jan. 26, 1929).

THE DEADLY PARALLELISM BETWEEN HIGH-SCHOOL AND COLLEGE COURSES IN CHEMISTRY*

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The Committee of Chemical Education of the American Chemical Society has made a valuable contribution to chemistry in its suggested outlines for high-school and first-year college chemistry. The data given on page 912 of the July, 1927, number of THIS JOURNAL, however, show that less than half of the high schools reporting pay any attention to the outline. We have no statistics as yet showing how many colleges are adapting their work for first-year students to the suggestions. Statistics given by the subscription department of the JOURNAL OF CHEMICAL EDUCATION at the St. Louis convention reveal that a discouragingly small percentage of our chemistry teachers are subscribers. It is therefore a matter of interest to the science of chemistry that every teacher who does appreciate the situation makes it a point to spread the new spirit of coöperation and coördination on every occasion when chemistry teachers meet for discussion of their professional problems.

The chemistry situation is quite typical as regards coördination between high-school and college courses. High-school credit in chemistry is accepted for entrance without question but right there, as far as numerous colleges and universities are concerned, the amenities cease. A great many institutions completely ignore the existence of the subject. The pupils with, as well as without, credit are dumped into the common freshman chemistry hopper and at the end of the course are ground out with the normal curve quota of *A*'s, *B*'s, *C*'s, etc. Frequently it has happened that the students with high-school credit have ranked among the lower grades, thus giving weight to the suspicion that the high-school year of chemistry was so much time wasted—the course was worthless.

Such a ruthless disregard for the time and effort of high-school teachers and pupils can exist only in states and communities where there is a sluggish public spirit. If the colleges be justified in their conclusions and consequent treatment, chemistry ought forever to be barred from the high-school curriculum as a useless and time-wasting exercise. If the colleges be wrong, then high-school teachers, principals, and superintendents ought to rise up and in indignation demand that a different treatment be accorded the subject. In places such recognition has been forced, although the solution of the problem has frequently resulted in an evasion of the issue rather than in constructive improvement.

Where such recognition of high-school chemistry has been granted the problem has been solved in one of three ways:

* Read before the Division of Chemical Education of The American Chemical Society at the St. Louis Meeting, April 17, 1928.

1. By arranging separate sections for those who have and have not had high-school chemistry—then proceeding to nullify the whole plan by giving to both sections the same course of lectures and identical laboratory work. However, every one who looks past the registration office knows this in no wise alters the situation—high-school chemistry is ignored. Such institutions still proceed on the assumption that the course in high-school chemistry is worthless or nearly so.

2. By giving the same course of lectures to both sections, covering the identical field but varying slightly the laboratory course for students having had the work in high school. This is a recognition of the fact that it might pay better to vary the course and not to compel the students to repeat the very things they did in the high-school laboratory.

3. By giving two entirely different courses, both as to text and laboratory, to the two sections.

We propose to show that this third method is the only way to deal scientifically and fairly with the problem. Also, we wish to point out that this is the only method that will serve to the advantage of chemistry as a subject. We are all desirous of having the student who goes through our courses come out saying, "that was a good course; I advise all freshmen to take it," rather than having him come out with a grouch and a grievance that warn all other students away. Such a student goes out into life with his mind set against chemistry as a tiresome subject that failed to interest him after having had one year of high-school and an additional year of college work. What such a student really had was a year of high-school chemistry and a year of *high-school chemistry grown up*, which he was forced to take in college.

How ridiculously true this statement is can be seen by comparing a high-school text in chemistry with a college text, especially if the same author has published both. Take a pair of such books; it will require less than five minutes to establish the *deadly parallelism*. Turn the leaves of the two books simultaneously: the chapter headings are the same, the same line drawings appear, the same etchings, the same industries are illustrated. If you examine the laboratory manuals you find the same instructions, the same experiments, the same methods. They both direct the preparation of oxygen, hydrogen, chlorine, nitric acid. The text may be the very best published, but consider the predicament of a student who, having used this author's high-school text, upon registering in the college chemistry course, finds himself confronted with his college text. The deadly parallelism will surely get in its deadly work. Such a situation must of necessity mean a serious blow to the interest in chemistry. The seriousness of it becomes apparent when we examine it in the light of human nature and common sense.

Very few people, as a rule, care to hear the same concert or read a book the

second time. If a man insists upon telling you the same thing twice you think there is something the matter with him—at any rate you are not interested. In short, we must have variety ourselves. The subject matter may be the same, but it must be treated in a new and interesting manner. In other words, in the ordinary walks of life, we object to any one springing a repetition on us, be it humorous story, book, lecture, or concert, but the very thing we object to for ourselves we propose to force our college freshmen into doing. They have had a chapter on oxygen—we give them an identical one in college; for the chapter on hydrogen—we give them a duplicate; they studied in high school about hydrochloric acid, chlorine, nitrogen, the atmosphere, etc.—we hand them the same chapters in college and expostulate on the general disinterestedness and modern-day lethargy of college freshmen.

Without ascertaining what experiments have been performed in the high-school laboratory (the students probably would not be able to enumerate them for us anyhow) we prescribe the orthodox course of experiments in first-year chemistry and more fuel is added to the fires of our indignation as the students refuse to become enthusiastic about heating iron filings and sulfur, holding a piece of burning magnesium ribbon, distilling ten drops of nitric acid from saltpeter, etc.

In a recent textbook of psychology we read: "A favorable attitude or disposition fosters its own growth and tends to perpetuate itself and thus it becomes a permanent state of mind . . . . . Learning is hard at best, and one should not make it more difficult by stimulating the wrong attitude." In any other line of life, we would not expect to create the right attitude by subjecting a person to excessive repetition. From the pedagogical point of view, educators are even now objecting to "making up conditions." They hold that there is a far deeper principle at stake than that of the removal of a condition mark from the books of the college registrar. The real educational question at issue is, will it harm or benefit the student? It is not so much the *record* that needs correction as the *student's mental condition*. Does the forced repetition of subject matter, now stale and often distasteful, benefit the student or will it produce a mind-set which becomes a permanent liability for life?

Surely we are inviting the wrong state of mind, a wrong attitude toward chemistry, when we force students to retrace every step taken in high school. Very often consequences are not only unfortunate, they are disastrous. Students pick up the textbook or listen to the first lecture and are shocked to find that the material is all familiar. That is just what they had in high-school chemistry. Whether or not they could pass a test in it, one thing they are sure of—*they have had it before*. This result of the first contact with college chemistry produces a mind-set; it creates an attitude. These chemistry lectures are not to be taken too seriously—as

for the laboratory experiments, they are all dull, monotonous, "old stuff." The consequences are: (1) a feeling of injustice at being compelled to retrace is aroused; (2) an attitude of sophistication and self-complacency develops; (3) a process of slipping and sliding is induced, finally resulting, all too often, in a *D* or worse. One thing has been accomplished which is both positive and lasting; an attitude of permanent and violent antipathy to chemistry has been established. As far as the students are concerned—"never again!" From the psychological point of view, therefore, it is very unscientific to ignore the students' previous training.

Why has the high-school course in chemistry gone begging so long for recognition? By recognition something more than the mere acceptance of the credit for entrance is meant. The course should be a pre-requisite leading to a course in college, entirely different from the grown-up high-school course. Surely we as college teachers are not so barren of initiative and devoid of ideas that we cannot devise a course in *general principles of chemistry* which shall make use of what the students have retained from high school, whether it be much or little, and yet be sufficiently unlike the preparatory treatment that it will not lead to the bankruptcy of chemistry. The course should make use of the principles already laid down and open up the possibilities of our science instead of curtailing and stifling the interest.

The failure to give such recognition comes from perfectly natural causes. We have run into a first-year chemistry rut. It begins with distinguishing between physical and chemical change and ends with the study of uranium, element number 92. We have come to consider it inevitable. We do not see the desirableness of getting out of it. Every teacher is anxious to find in his students a goodly basis of prerequisites upon which to build his course. Failing to find them, he condemns the preparatory training whose business it was to lay the foundation. Too often the college teacher has advanced so far beyond his own secondary school days that he has forgotten both the method and the substance of what he went through, but he makes rigid requirements as to the preliminary knowledge a student must bring with him into freshman chemistry. Let us be reasonable. If a high-school graduate does not know how to write the equation for copper plus nitric acid or cannot show how potassium permanganate breaks down, let us ask ourselves the question—could we have written the formula for the value of x in the quadratic equation one year after we "finished" algebra? How many of us can extract square root, to say nothing about cube root? As for history most of us should probably have to confess that we are in the same class as the student who remembered only one date in church history, but had forgotten what happened in that year.

After a year's work of high-school chemistry there is bound to be a minimum residuum of terms, facts, and figures which we should take for

granted and expect the students to possess. They have a chemical vernacular, and understand elementary chemical language. In a mixed class of the two kinds of students it is necessary to begin by teaching the language of chemistry—definitions, spelling, explanations of the simplest terms. The high-school graduate with chemistry credit has his intelligence insulted by listening to the teaching of the *ABC*'s. On the other hand, in a section of advanced students it is not necessary to define element, chemical change, valence, Boyle's law, atomic and molecular weights—these can be taken for granted. The students should be made to realize this. Then if they are not in possession of the facts, the responsibility is theirs, and they must look up the high-school text and review the prerequisites. The teacher has sufficient opportunity to test the students' knowledge and can purposely review that material which seems necessary.

By such a course the high-school student feels that he is promoted instead of marking time; he makes use of all he brings with him, his memory is stimulated, his curiosity aroused, his self-respect is maintained—in short, chemistry is being taught on the basis of good psychology and correct pedagogy—the minds are stimulated instead of being rendered stagnant and indolent.

Yale Gets Institute for Study of Human Relations. Something entirely new in the development of science and its application to human affairs is planned for Yale University, in the building at New Haven of an Institute of Human Relations. Gifts and subsidies representing a capital of $7,500,000 will go toward the establishment of an organization within the University, whose function it will be to bring to the study of human life, as it goes on in the world every day, all the massed assets of science. It will act as a point of liaison for hitherto separated and largely unrelated branches of knowledge and technic, such as the social sciences, psychology and psychiatry, biology, medicine, and law. Each member of its staff will also be a member in full standing of the regular university department in which his science is represented, so as to maintain contact with the entire university group.

Although a startling innovation, the Institute of Human Relations is, according to Pres. Norman Angell, a logical development of the best tendencies in modern education and research. It is designed to permit progress which cannot well be made as long as sharp lines divide the various branches of science from one another in educational institutions. It is based on the belief that speaking precisely, the living human body and the human mind are not separate, but interdependent entities, and that, in like manner, the individual and the social group can be understood only in relation to each other.

The principal contributors to the support of the new organization are the Rockefeller Foundation, the Commonwealth Fund, and the Laura Spelman Rockefeller Memorial. For a building to house the institute $1,500,000 will be expended; $100,000 a year will be used for the next ten years in the development of the program in psychiatry; and $150,000 a year for a like period will be devoted to research in the social sciences and for continuance of research in child development and psychology.—*Science Service*

THE ONE COLLEGE CHEMISTRY COURSE FOR FRESHMEN

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Much has been written on the question of whether students entering college with high-school chemistry should or should not be given a separate course in the science. Harry Shipley Fry[1] maintained that a college course suitable for all high-school students can be given. W. A. Everhart and W. C. Ebaugh,[2] from a study of the results obtained by giving all students the same lecture and recitation work but different laboratory work, advocated a classification of high-school students into sections according to "demonstrated ability" with occasional shifts from section to section as the need arises. F. E. Brown[3] concluded that a separate course should be given to students who have had high-school chemistry since students so grouped do better work in later courses in chemistry. Alexander Silverman[4] agreed with F. E. Brown since he found that the percentage of students doing superior work is thereby increased.

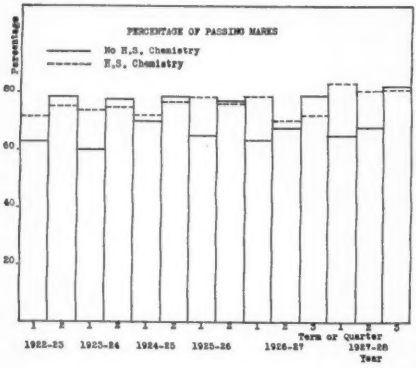

FIGURE 1

At the University of Tennessee but one course is given to freshmen taking chemistry. During the past six years the grades of these students have been compiled carefully with the hope that this information might be of some value in determining the advisability of having separate courses. This article deals with a study of these grades.

The percentage of passing marks (65 or above) is shown in Figure 1. It will be noted from this figure that the number of passes during the first term or first quarter is much less (with the exception of 1924–25) among students with no previous chemistry. On the other hand, the inverse is true during the second term from the years 1922 to 1926. At the beginning of the year of 1926–27 the University went on the quarter system. From this point on, the students with no previous chemistry do not exceed until the third quarter. Another point of significance in connection with Figure 1 is the fact that the students with no previous chemistry always improve

[1] THIS JOURNAL, **2**, 260 (Apr., 1925).
[2] *Ibid.*, **2**, 770 (Sept., 1925).
[3] *Ibid.*, **3**, 301 (Mar., 1926).
[4] *Ibid.*, **5**, 317 (Mar., 1928).

after the first term or quarter. In other words, they are on the upward trend. This is not true, particularly recently, of the students with previous training in chemistry. As a rule this group seems to do the best work at the beginning of the college year, but their record is on the decline.

How are we to account for this decline in the number of passing marks among the high-school trained group? Several reasons suggest themselves. Possibly the work is so easy that this group acquires it with little effort and as a result forms loose habits of study which account for the later higher fatalities. Possibly the subject matter at the beginning contains too much review material with the result that the science becomes uninteresting to this group. It is, no doubt, true, too, that the psychology of a mixed group of this kind is bad. Students with no previous training feel that they should not be made to compete with high-school trained students. The latter do good work at the beginning since their status in college has not been determined, but later they become more certain of themselves, possibly over-confident, especially since they are working with a considerable number of classmates with no previous chemistry and, as a result, their passing record goes on the downward trend.

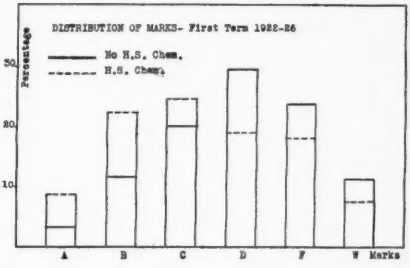

FIGURE 2

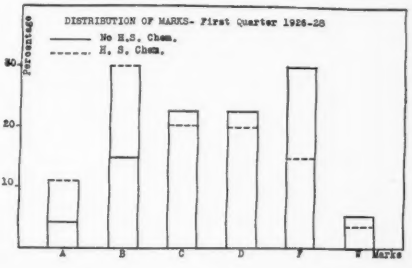

FIGURE 3

The system of grading used at the University of Tennessee is as follows:

A = 95–100	D = 65–75
B = 85–95	E = below 65[5]
C = 75–85	W = withdrawn

[5] Condition marks are given to some, slightly below 65, who, in the opinion of the instructor, may be able to pass another final examination. In this compilation all condition marks were placed with the marks into which they had been converted by the students with the exception of those acquired during the third quarter, 1928. In this case it was necessary to estimate the final marks since these people do not remove these condition marks until the fall.

The distribution of marks in percentages for both classes of students is shown in Figures 2, 3, 4, 5, and 6. From Figures 2 and 3 it can be seen that the student with high-school training stands about two and one-half times more of a chance of getting an A during the first term or quarter than his classmate with no previous chemistry. The same Figures show that the trained student has approximately twice as much of a chance of getting a B. The variation among C's and D's is not so pronounced during this term and quarter. In the case of the F's, as shown indirectly in Figure 1, the untrained students have the greater percentage. This percentage is much greater by the quarter system, probably due to the fact that the students with no previous training do not have quite as much time to become accustomed to the nature of the work.

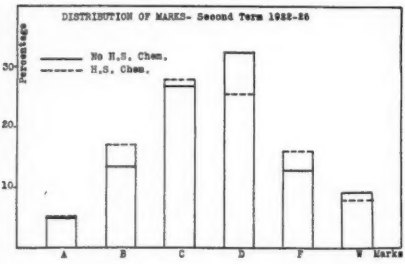

FIGURE 4

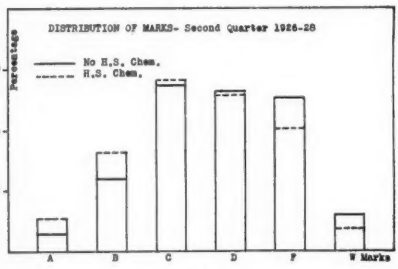

FIGURE 5

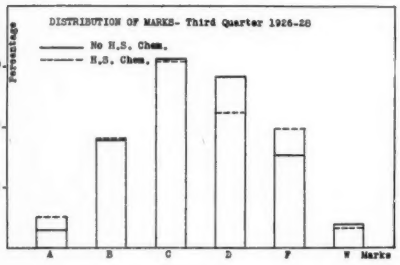

FIGURE 6

During the latter portion of the student's work (Figures 4, 5, and 6) the variation between the percentages of A's and B's is not so great although, as a rule, the students with previous training stand a better chance of getting such a mark. The percentage of F's is greater among the untrained students during the second quarter (Figure 5) but during the second term (Figure 4) or third quarter (Figure 6) a greater number of students with previous training fail.

Summary

A study of the grades made by all students taking one general chemistry course at the University of Tennessee shows that:

(1) Students with high-school chemistry make a better record during the first part of the work and they always stand a better chance of getting an *A* or *B*.

(2) Students with no high-school chemistry have the better record during the latter portion of the work. Several suggestions, which may account for this superiority on the part of the untrained students, are given.

Benzene Poisoning in Chemical Laboratories. A study of the toxic effect of benzene fumes led Bloomfield to investigate conditions in chemical laboratories. He found that considerable amounts of benzene were used in laboratories where tests are made with rubber, paint, varnish, and oil products.

Benzene is employed for cleaning apparatus and even for the cleaning of the hands and arms of laboratory workers. As a result, the concentration of benzene in laboratory air has been found to vary between 28 and 223 parts per million.

A concentration in the air as low as 100 parts per million is considered to constitute a definite hazard.

However, since laboratory exposure to benzene is likely to be intermittent, study of vapor concentrations is not as trustworthy a method of establishing the presence of danger in laboratories as are blood examinations of those exposed.

The United States Public Health Service has accepted, as evidence of toxic effects, a fall in the leucocyte count below 5600 per cubic millimeter of blood. Bloomfield found in three of the workers he examined a disturbance in the relative proportions of the various types of white blood cells. He interprets this as evidence that the possibility exists of benzene poisoning among laboratory workers.

It is believed that benzene should be replaced with a less toxic solvent.—*Laboratory*, **2**, 13 (1929).

Plant Lice Routed with Disease Spore Spray. The visions of horror, entertained by some novelists, of a future war wherein aviators will drop deadly disease germs instead of bombs or gas, have been realized in the war that scientists are waging on the insects that devour crops and orchards. Insects no less than men are subject to germ diseases, only their taking off is accomplished perhaps more frequently by fungi than by bacteria.

The latest addition to the list of insects which have proved vulnerable to attack with a spray loaded with the spores of a parasitic fungus is the common aphid, or "plant louse" of egg plants, peppers, and other vegetables. J. A. B. Nolla, Porto Rico phytopathologist, killed the majority of the hosts of these pests that swarmed on plants under his care with a spray of suspended spores of the fungus known as *acrostalagmus aphidium*.

The practical extension of the use of spore attack on insect pests depends largely on getting a sufficient and cheap supply of the fungus. Farmers cannot raise their own fungi, because it requires greater technical equipment than the average farmer commands. Commercial insecticide manufacturers could hardly undertake to raise the fungi, because their copper and lime dusts are poisonous to it. Waste mash from distilleries might prove a practicable medium in localities where distilling is still a permitted industry.—*Science Service*

HIGH-SCHOOL CHEMISTRY AND THE STUDENT'S RECORD IN COLLEGE CHEMISTRY

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The question of the value of high-school chemistry to those students who subsequently take college chemistry has never been settled. Much verbal comment has been made, often to the effect that the advantage of a high-school course is valueless to the college student of chemistry. Some papers containing statistical evidence have been published and it is to this list that the authors wish to add.[1,2]

In this college the students taking first-year college chemistry are all women; most of them are freshmen, but some are sophomores, and two or three each year are upper-class students. All of these are included in the averages given below.

Some calculations were made to determine whether sophomores did any better than freshmen in the same work, and it was found that 615 examination grades from 88 sophomores (and upper classmen) averaged 60.9 per cent while 883 grades from 118 freshmen averaged 58.3 per cent. This difference of 2.6 per cent is small and probably of slight significance. However, the sophomores were almost invariably higher in the first examination of the year and also in the mid-year and June finals which are the times of maximum effort; but more of these freshmen than sophomores left college before graduation which could account in part for the difference in grades since the poorer students drop out in greater numbers.

Examination Grades

The grades given below are for the written tests given about the same time each year and for the final examinations given at the end of each semester. No class recitations or other incidental grades are included because they contain a greater personal element. For the first two years there was one lecturer and one laboratory assistant. For the last three years there were two lecturers and a total of seven different laboratory instructors.

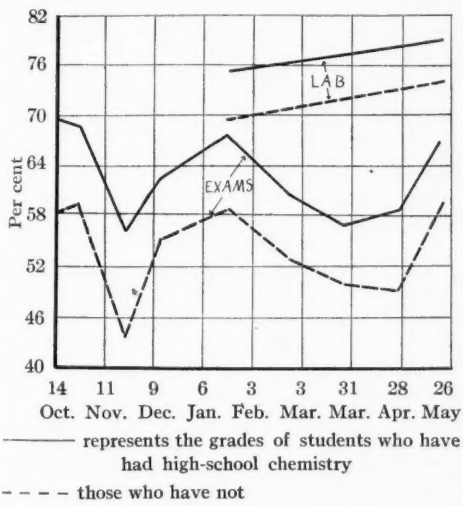
Date	Oct. 14	Oct. 28	Nov. 23	Dec. 12	Jan. 20 Final	Feb. 23	Mar. 27	Apr. 27	May 22 Final
Number of students+	174	104	202	143	216	198	139	180	197
Grades+	69.4	68.6	56.2	62.4	67.8	60.2	56.7	58.4	66.3
Grades−	58.5	59.5	43.2	55.5	58.8	52.7	49.7	49.1	59.3
Number of students−	113	69	123	93	133	118	84	109	113

\+ Students who have had high-school chemistry.
− Students who have not had high-school chemistry.

[1] Fry, THIS JOURNAL, **2**, 260–9 (April, 1925).
[2] Everhart and Ebaugh, *Ibid.*, **2**, 770–4 (Sept., 1925).

The foregoing table shows the composite, weighted averages for the five-year period, 1919–23 inclusive.

The grades of all students who took each examination are included in the average for that date. Absences account for the irregular number of students at the different dates as well as the fact that in a few cases the examination for that date was not given. The weighted averages of all the above grades show that 1553 examination grades made in general chemistry by 216 different college students who have had high-school chemistry average 62.8 per cent; while 955 grades made by 133 different students in the same classes, who have not had high-school chemistry, average 53.8 per cent. Not only was the general average 9 per cent higher but the former were also from 7 to 11 per cent higher in each examination. This consistency in difference between the grades of the two groups is shown more clearly by the following curves.



——— represents the grades of students who have had high-school chemistry

- - - - those who have not

Laboratory Grades

The laboratory grades were compiled at the end of each semester only, and so only two values were available. It was found that 214 students with high-school training in chemistry averaged 74.9 per cent in our classes at the midyear, while 129 students without high-school training averaged 69.6 per cent. At the end of the year, 204 students of the former class averaged 78.8 per cent and 126 of the latter group averaged 74.0 per cent. These values are also given on the above curve chart.

Discussion of Results

The grades used in this paper were given without prejudice as our rolls contained no information as to who had offered credit in high-school chemistry, and no effort was made to get the information, for it was thought at the time that the previous training made little difference. By 1924 it was found possible to maintain separate sections for students of different ability and then the compilation of the above data from our records and those of the registrar began.

Most of the students were from the high schools of New Jersey which rank well up the list in their equipment for teaching chemistry,[3] the exact rank depending on the relative weight allowed for the various factors (equipment, library, teacher's training, and so on). Some indication of the results of the teaching in these high-schools is given by the records of the men students of Rutgers who have been trained in much the same high schools as the women whose grades are given above.[4] These men ranked second in the list of records from fourteen widely distributed colleges, in the Iowa Chemistry Training Test. It would seem, then, that the high-school training is somewhat better than that of the country as a whole.

No dogmatic interpretation of these results should be made, but they seemed to us to show sufficient difference to warrant separate sections, and so, since 1924, separate sections of liberal arts students have been maintained in general chemistry. Subsequent experience has justified the separation in the opinion of the teaching staff, although a change in the system of grading has been made and so statistical comparison is of little value. If students are arranged in the familiar groups denoted variously as, *A*, *B*, *C*, *D*, or as excellent, good, average, poor, and failed and the like, then the differences shown are almost sufficient to place the average student who has had high-school chemistry one group higher than the average student who has not had such a course.

It is, of course, impossible to say definitely what the reason for this difference is. The authors feel that it is not the facts that are remembered, but rather the student's familiarity with the language and nature of the subject and also the fact that some of the work is repetition. To the beginner everything is new and unfamiliar and so much time and energy must be spent in mastering the most elementary and mechanical phases of the subject. Possibly some of the difference is due to the tendency of the better students to elect high-school chemistry and the poorer to avoid it because of its difficulty.

One factor brought out by the curves deserves emphasis; namely, the position of the maxima. These points represent the student's maximum effort. They lie farthest apart for the two groups at the beginning of the term and closest at the end of the year. For both classes the curves show the ambitious start, the well-known slump, and the desperate recovery. This attitude of students toward their work is one of the greatest difficulties in predicting their performance and also in designing the courses.

That the difference in the laboratory grades of the two groups was less than that of the examination grades and that it was maintained throughout the year were both unexpected. However, the individual aid given by

[3] THIS JOURNAL, **4**, 911–3 (July, 1927).

[4] Cornog and Stoddard, *Ibid.*, **3**, 1408–15 (Dec., 1926).

laboratory instructors and the less exact method of grading experimental work may account for these features of the differences.

While the final combined grades which we record with the registrar are not included in this paper, they have been averaged and while the differences are somewhat less than those of the examination grades, they are of the same order.

Graphite in the United States. Natural graphite is used chiefly in the manufacture of foundry facings, pigments and paints, crucibles, pencils, commutator brushes, stove polish, lubricants, retorts, and batteries. During the last few years the use of graphite in the United States has undergone radical changes. Uses that a few years ago consumed a large proportion of the supply are now relatively of minor importance, and uses which were unimportant have become important. Before the war the manufacture of graphite crucibles consumed more than one-half of the supply; in 1923 only 15 per cent of the graphite used in the manufacture of finished products was used in the manufacture of crucibles, and in 1924 only 13 per cent. Foundry facings used only 10 per cent of the graphite in 1913; the quantity so used in 1923 was 44 per cent, and in 1924 it was 52 per cent. Other uses that were minor before the war and are now of much importance are in pigments and paints, pencils and crayons, commutator brushes, stove polish, and lubricants. Graphite is manufactured at Niagara Falls, N. Y. This branch of the industry was started in 1897, under patents obtained by Dr. E. G. Acheson, and was developed so rapidly that after 10 years the production of artificial graphite exceeded that of natural crystalline graphite. Since 1910, except for 1915 and 1920, the output of manufactured graphite has exceeded annually the combined output of domestic amorphous and crystalline graphite. Statistical information in regard to the production of graphite in 1927 is given in a paper recently issued by the United States Bureau of Mines, copies of which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 5 cents.—*Chem. Age*, **19**, 395 (Oct. 27, 1928).

New Czechoslovakian Chemical Journal. Owing to the limited number of readers who understand Czech, the Czechoslovak chemists have hitherto published their chief works in journals outside their own country. Nevertheless, many important communications still remained untranslated in the archives of the Czech learned societies and institutions. This circumstance has not allowed a real international knowledge of the actual chemical scientific researches carried out in Czechoslovakia. A new journal entitled *Collection of Czechoslovak Chemical Communications* has therefore been established under the joint editorship of Professor E. Votocek and Professor J. Heyrovsky. The first number, which has just appeared, contains four papers—three in French and one in English, and presumably it is intended to publish all papers in the commoner languages of science. The editors state that this journal has been founded in order to publish in full extent the more important communications concerning "pure" chemistry, provided they have not previously been published in any widely known language. Besides this, the *Collection* will include a bibliography of all publications of Czechoslovak chemists and reviews of their books. The venture is aided by the Czechoslovak Board of Education, and is under the patronage of the Bohemian Royal Society of Sciences. It will appear monthly, the annual subscriptions being equivalent to 26 Swiss francs, *i. e.*, 170 Kc (£1). Subscriptions may be forwarded to Professor J. Heyrovsky, Charles University, Prague II, Albertov 2030, Czechoslovakia; or to Dr. G. Druce, 26 Heslop Road, London, S. W. 12.—*Chem. Age*, **20**, 98 (Feb. 2, 1929).

A FILING AND RECORD SYSTEM FOR LABORATORY KEYS

BURTON J. OTTE, UNIVERSITY OF FLORIDA, GAINESVILLE, FLORIDA

For some time the writer has been trying to find an ideal system of keeping laboratory keys and, at the same time, a record of the holder of the key. All systems investigated or described seemed bulky and cumbersome. Ordinary key cabinets are of small capacity, and large cabinets having removable panels are not satisfactory. They occupy a large amount of space and the keys are apt to fall off the board if dropped.

Our present system requires a $2^1/_4'' \times 3^1/_2''$ pay envelope containing one of the key cards now in use. These envelopes have the locker number and the key number typed on them and are filed according to the locker number. A standard filing cabinet, called an impairment record file, holds these envelopes in their upright position, thus making it easy to remove a key or a key card without removing the envelope. The cabinet is $12^1/_2''$ wide, $27''$ deep, and $52''$ high, and has ten drawers each with four compartments. The capacity of each drawer is from 300 to 400 envelopes, each envelope containing four keys or cards. Thus one drawer accommodates all the keys of a large laboratory. Not needing, at present, all the key space available, we had one drawer made to care for two sets of $3'' \times 5''$ cards, and two other drawers have been replaced by one standard invoice file drawer.

The drawers are removable so that when lockers are being assigned a drawer can be taken, for convenience, to the stockroom window. Keys for small laboratories and keys needed during the day are secured from the Curator's office where the file is kept locked at all times. All building keys are also kept in this file.

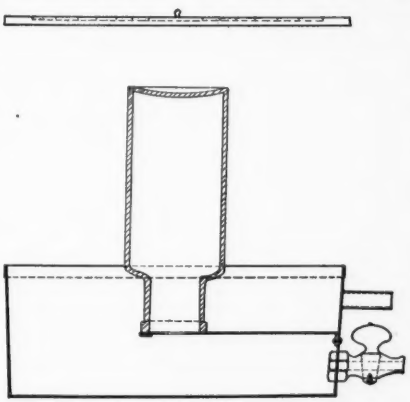
Up to the time that we established this system at the University of Florida, considerable difficulty was experienced in making the students check the equipment in their locker and turn in their equipment list. Now when a locker is assigned it is first opened by a pass key in the possession of the instructor. Then after it is checked in and the key card completely filled out, the student is given his key. The key card, as illustrated by the sample, is placed in the small envelope where it remains until the key is returned. If a key is lost this fact is recorded on the card and, in addition, the date that the student checks out, the card remaining in the envelope until a new lock is put on the locker. When several keys are lost and the locker is being opened by lost keys the locks may be changed or a new lock put on the locker.

Name.....	
Home Address.....	
College Address.....	
Course No.....	
Locker No.....	Key No.....
FIRST SEMESTER	SECOND SEMESTER
Date in.....	Date in.....
Date out.....	Date out.....

A COMBINED PNEUMATIC TROUGH, STEAM-, AND WATER-BATH

C. R. HOOVER, WESLEYAN UNIVERSITY, MIDDLETOWN, CONNECTICUT

There are certain obvious objections to providing permanently installed steam- and water-baths in sufficient number to meet the varying and occasional needs of elementary chemistry students. Make-shift conversions of sinks into pneumatic troughs present objectionable difficulties. There is therefore a need for simple, inexpensive apparatus to be used for evaporations and collection of gases. To supply an elementary student with individual pneumatic troughs and steam- and water-baths is unnecessarily expensive, and these bulky pieces of apparatus are inconvenient to store in lockers. If it is arranged to have a common supply of such apparatus used by several sections in turn, parts of the apparatus are frequently lost or rendered inoperative due to misuse. Since it is seldom, if ever, necessary to use any two of the three previously mentioned pieces of apparatus at the same time, we have designed a combination outfit which serves equally well for all of the purposes just discussed. The combined water-bath, steam-bath, and pneumatic trough is illustrated in the accompanying figure.



BATH ARRANGED FOR USE AS PNEUMATIC TROUGH

As made in this laboratory, the device consists of a spun, sheet-copper vessel, 20.5 cm. in diameter and 8 cm. deep. Near the middle of the vessel a copper shelf extends over slightly more than one-half of the cross-sectional area and is fastened by rivets or hard solder. An opening near the front edge of this shelf allows for the delivery of gases. The simple brass stopcock is attached by means of a brass nut, and the upper tubing connection is attached with hard solder. For use as a pneumatic trough, the stopcock is closed and the vessel filled with water to the level of the upper connection which leads through rubber tubing to a waste water outlet. The shelf provided in the apparatus will support four 250-cc. bottles, which can be collected separately and allowed to remain on the shelf after filling. For use as a water-bath, a standard set of 20.5-cm. concentric copper rings is placed on the vessel, the stopcock is closed, and water added to some convenient level. The bath has sufficient water capacity to provide steam for a laboratory period of the usual length, but it

is possible to attach a water supply to the lower tube and run a connection from the upper tube to a drain and thus have a somewhat inefficient but, nevertheless, effective constant level bath. When functioning as a portable steam-bath, the apparatus is connected to a steam cock through the upper inlet and through the stopcock condensed water is drawn away to a drain. The tubing used for connecting the bath, when it is used with steam, is tubing which has been returned by students after one year's use. While copper has been found to be most satisfactory as the material for the construction of this piece of apparatus, cheaper baths can be prepared by the use of lead-coated iron.

Tracing Cloth Found Transparent to Ultra-Violet Rays. Ordinary tracing cloth, such as draftsmen use for their drawings that are to be blueprinted, is likely to become a favorite curtain material on account of a discovery by C. H. Young at McGill University.

Incidental to investigation of the effect of ultra-violet light on blueprint paper, Mr. Young found that the beneficial short wave-length radiation from the sun will pass through the tracing cloth, although the ordinary paper and cloth act as a barrier. A single layer of tracing cloth will, moreover, screen off much of the heat.

He suggests that a single thickness of tracing cloth between wide-meshed wire screens can now replace curtains and blinds and with this screen before an open sunny window it will be possible to enjoy the advantages of ultra-violet light without undue heat or glare. The eyes should be protected, however.

Ultra-violet light, invisible to the human eye, is necessary for healthy growth of human beings and animals. Since the effectiveness of sunlight and artificial ultra-violet light in preventing rickets and aiding other disease treatment has been recognized, many glasses and glass-like substances transparent to ultra-violet light have been placed on the market.

Mr. Young believes that tracing cloth will provide a cheap and effective substitute for these many special glasses and that the material hitherto confined to drawing-boards will find its use in sun-parlors, country cottages, and on chicken farms.—*Science Service*

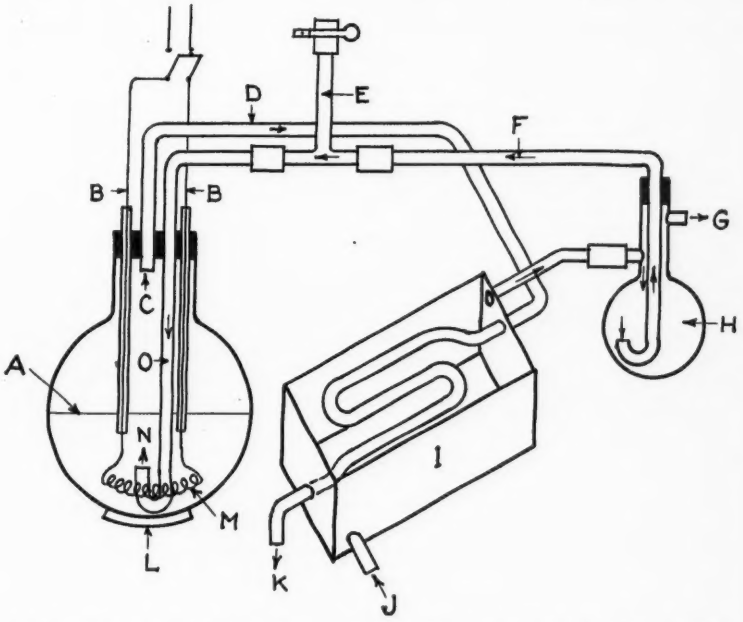
Deep Lake May Irrigate Armenia. The droughty fields of Russian Armenia may have their crops increased by water from Lake Sewang, a great body of water with a surface area of 464 square miles. It has often been proposed to use this water for irrigation, but the authorities have always hesitated to take action because of the general impression that the lake was of volcanic origin and comparatively shallow, and hence that its water resources were relatively limited.

Recently, however, a special commission of the Russian Academy of Sciences has made a careful examination of the geology of the lake, and has discovered that it occupies a natural deep rock basin, similar to that in which Lake Superior lies. Its average depth is over 300 feet, and since it receives not only numerous surface streams but also the discharge of large subterranean rivers, it is believed that it contains so much water that the removal of a part for irrigation will not seriously affect its level. The erroneous impression that the lake was of volcanic origin arose from the presence along its shores of numerous lava masses which have been proved to be of more recent date than the rivers that flow into and out of it.—*Science Service*

AN ELECTRIC WATER STILL*

GILES B. COOKE, UNIVERSITY OF MARYLAND, COLLEGE PARK, MARYLAND

A very efficient and convenient form of water still is described below. This still is easy to construct. After starting it requires no attention to operate. The water from this still is very pure. By using electricity, gas flame, which is dangerous where inflammable, volatile solvents are necessary, is eliminated. The still is efficient, hot water from the top of the cool-



A—Water level; *B*—Copper wire; *C*—Steam outlet; *D*—Block tin pipe; *E*—Tube for drainage; *F*—Hot water; *G*—To drain; *H*—Hot water; *I*—Pneumatic trough; *J*—Cold water inlet; *K*—Distilled water outlet; *L*—Straw ring support; *M*—Heating coil; *N*—Hot water inlet; *O*—Glass tube.

ing tank passing to the liter flask and siphoning into the still. A twenty-liter bottle can be filled in five hours.

A coil of resistance wire is placed in the bottom of a twelve-liter flask and covered with water. Six feet of wire are used for 110 volts. The flask is kept about one-half full of water. Two copper wires, each inside glass tubing, are led to the heating coil. Connection is made by use of leads,

* No originality is claimed for devising this water still. It is simply offered by the writer for any value it may have.

soldered to the copper wires. A piece of block tin pipe extends from the neck of the flask to a pneumatic trough. The tin pipe enters one end of the trough near the top, is coiled around inside the trough and passes out near the bottom at the opposite end. The places where the pipe passes through the ends of the trough should be soldered. Cold water enters one side of the trough near the bottom, and passes out near the top at some convenient place. Short pieces of copper pipe, soldered to the trough, make convenient water outlets and inlets. From the trough, the water passes through a rubber tube to a one-liter flask. The water enters the flask by means of a side arm on the neck, fills the flask, and flows out through another side arm. From the bottom of this flask a glass tube extends to the bottom of the still, and through it water siphons into the still. The curved ends prevent air bubbles entering the tube and breaking the siphon. A four-hole rubber stopper closes the still. If the boiling water splashes, a Gooch crucible may be wired over the end of the tin pipe.

Below are listed the materials necessary to construct this water still.

1 twelve-liter flask (pyrex) (Size optional)
1 pneumatic trough
6 ft. glass tubing (pyrex)
5 ft. block tin pipe (copper pipe could be used)—inside dia. $1^1/_2$ cm.
1 one-liter flask
5 ft. rubber tubing
1 rubber stopper No. 11
1 small roll tape
1 straw ring support (or cork)
2 short pieces of copper pipe
2 ft. copper wire No. 12
6 ft. resistance wire[1] (for 110 volts)

[1] The resistance wire used is Chromel A. Size 24—1.53 ohms per ft. Made by Hoskins Mfg. Co., 4445 Lawton Ave., Detroit, Mich.

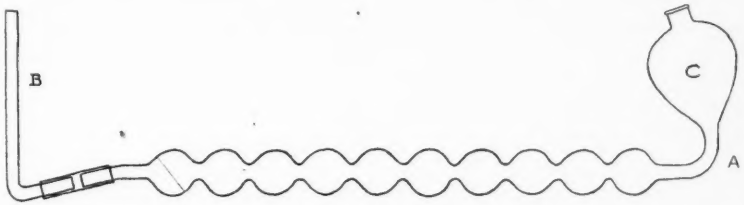
Ramsay Memorial Fellowships. The Ramsay Fellowships in Chemical Science—British, Dominion, and Foreign—which are tenable in the Universities and University Colleges of the United Kingdom, are at present held by the following. In each case the University or College which has been selected by the Fellow for his research is given: *British Fellowships:* Dr. A. M. Taylor (University of Cambridge), Dr. R. H. Purcell (Imperial College of Science and Technology, London). *Glasgow Fellowships:* Dr. Peter Maitland (University of Cambridge), Miss Irene McAlpine (Special Fellowship, University of Glasgow). *American Fellowship:* Dr. R. H. Dalton (University of Oxford). *Canadian Fellowship:* Dr. W. H. Barnes (Royal Institution, London). *Danish Fellowship:* Miss A. M. Unmack (University of Oxford). *Greek Fellowship:* Dr. D. Nider (University College, London). *Japanese Fellowship:* Dr. Yohei Yamaguchi (University College, London). *Netherland Fellowship:* Dr. H. Bienfait (Imperial College of Science and Technology, London). *Swedish Fellowship:* Mr. H. Liander (University College, London). *Swiss Fellowship:* Dr. G. Schwarzenbach (University College, London). The total value of the annual amount of the Fellowships that is awarded is approximately £4000, of which about £3000 is provided by grants from Dominion and foreign sources.—*Chem. Age*, **20**, 75 (Jan. 26, 1929).

AN EXPERIMENT DEMONSTRATING THE SLOW MISCIBILITY OF TWO LIQUIDS OF DIFFERENT DENSITIES

THOMAS G. THOMPSON, UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON

The experiment outlined below was devised to illustrate the small degree of mixing which occurs when two readily miscible liquids of different densities are permitted to come in contact with each other. The experiment was originally designed to illustrate the flow of sea water into fresh water systems[1] and to show the relatively small degree of mixing resulting from such a disturbance. The author has noted that the experiment has been of considerable interest to freshman chemistry students. He has also used it in his introductory lectures on volumetric analysis to impress the student with the necessity for thorough shaking in the preparation of standard solutions.

The experiment is best performed with Meyer bulbs as shown in the accompanying figure. The apparatus is completely filled with fresh water up



to the point A. B is a piece of glass tubing connected to the Meyer bulbs by means of rubber tubing. The apparatus is clamped in a horizontal position and about 70 ml. of solution of a salt, acid, base, or sea water added to C. The solution is colored with a suitable indicator before it is introduced into C. Because of its greater density the solution tends to settle to the bottom, and flows into the first bulb of the series, gradually filling the lower portion of the bulb. The displaced water tends to flow upward into C. As soon as the lower part of the first bulb has been filled with the more dense liquid, flow into the bottom of the second bulb will commence. This process will continue until the lower portion of all of the bulbs has been filled with the colored solution, the upper part, containing the less dense solution, remaining colorless. When this has occurred it will be noticed that the water has displaced considerable of the colored, more dense solution formerly in C, thus showing that it was possible for the water to work its way through the more dense solution in the tube connecting C and the bulbs, with only a small degree of mixing.

[1] Smith and Thompson, *Ind. Eng. Chem.*, **17,** 1084 (1925); *Bull.* **41,** Univ. Wash. Eng. Exptl. Sta. (1927).

TWELFTH EXPOSITION OF CHEMICAL INDUSTRIES

The Twelfth Exposition of Chemical Industries which will open at the Grand Central Palace, New York City, May 6th to 11th, bringing together thousands of chemists, chemical and research engineers, manufacturers and buyers from forty odd industries, is particularly significant of the advancement made in the chemical industries field during the last quarter of a century.

The various groups of this important industry as represented at the exposition will exhibit the most modern equipment and advanced practices of chemical engineering and chemistry. A cross-section of the metals group shows fifteen exhibitors who will show various alloys and include such outstanding producers as Crucible Steel, Vanadium Steel, International Nickel, Duriron, Inert Metal Products, Inc., Industrial Welded Products Co., Carpenter Steel Co., Globe Steel Tube Co., Titusville Forge Co., Nelson Metzler Corp., Lalance-Grosjean Mfg. Co., Ludlum Steel Co., Central Alloys Steel Co., Babcock & Wilcox Tube Co., and Fansteel Products Co. For the first time there will be exhibited a new acid-resisting alloy by Krupp. This metal has many special and unusual features that will be of great interest to the chemical industry. Considerable research and new development work has been undertaken during the past year in perfecting special alloys. The latest discoveries in this field will be presented in attractive displays by foremost manufacturers in this field of endeavor.

In the Laboratory Supply and Equipment group a large number of interesting exhibits will be assembled: exhibits of laboratory furniture; general laboratory apparatus and supplies; special laboratory equipment; filter papers; optical instruments; laboratory chemicals; platinum ware; instruments of precision; electrical apparatus; laboratory balances; glassware, porcelain, silica ware, and plastic compositions. This group will have in its various exhibits complete displays, charts, and graphs of all equipment and the functions it is designed to perform.

The Instruments of Precision group will have a number of exhibits, among which will be an exhibit of a spectro-photometer and hydrogen-ion colorimeter. These two will be of particular interest to the color and dye industry. The hydrogen-ion colorimeter is new and will be exhibited at the Exposition for the first time. A number of balances, microscopes, high-temperature furnaces, and color analyzing apparatus will also be exhibited. A new method of connecting vitreosil pipe lines will be presented at the coming Exposition.

Attendance at the Chemical Industries Exposition is confined almost entirely to users and buyers of chemicals and chemical equipment. Admission is gained only by invitation and registration. There are no tickets sold. To the last Exposition there came 67,000 men looking for ideas and information to aid them in the conduct of their business. This picked group of interested visitors came from 810 cities and towns in 40 States and 119 cities and towns in 39 foreign countries.

At the Exposition this year, Export Day, Thursday, May 9th, will be awaited with much interest by the foreign representatives and special attention will be given this feature by various exhibitors who plan to have their Export Managers and Foreign Sales Departments in their booths to give every possible assistance to foreign buyers.

The Students' Courses are being arranged and speakers assembled for the various lectures. The course will be under the direct supervision of Dr. W. T. Read, Professor of Chemistry, Texas Technological College, and the enrolled classes promise to exceed the record of 162 special students who attended the complete course at the last Exposition.

Many other groups including the Container, Southern, Canadian, and Food Producing Equipment sections, will be discussed in more detail at a later date.

THE COLUMBUS MEETING

Attention is called to the preliminary notice which appears on page 19 of the January issue of the JOURNAL OF CHEMICAL EDUCATION.

The Symposium on Lecture Experimentation will afford an unusual opportunity for the following types of displays: (*a*) exhibits by manufacturers and distributors of lecture demonstration and other apparatus for chemical laboratories; (*b*) exhibits of high-school and college student laboratory projects, including graphs, charts, and photographs; (*c*) exhibits of new or unusual charts and apparatus set-ups used in the teaching of chemistry.

Free space in the chemistry building of the Ohio State University will be reserved on request, provided wall or desk space is specified. The local committee will also be glad to receive and put on display any exhibit and will do its best to guard against breakage or loss although it cannot assume responsibility. Exhibitors will be expected to bear the cost of transportation in both directions and for the packing. All exhibits to be mounted by the committee should be in its hands not later than Thursday, April 25th, and no exhibit, except by special arrangement, is to be removed from the display earlier than Thursday noon, May 2nd.

All communications relative to the above exhibits should be addressed to the Local Secretary of the Division, Dr. Jesse E. Day, Department of Chemistry, The Ohio State University, Columbus, Ohio.

A breakfast meeting of the Executive Committee has been scheduled for 8 A.M., April 29th, and a breakfast meeting of the Senate of Chemical Education for 8 A.M., April 31st. The editors and contributing editors of the JOURNAL OF CHEMICAL EDUCATION will meet at 5 P.M., Wednesday, April 31st. On either Wednesday or Thursday of convention week, the Division will have as its guests at luncheon the local high-school teachers of chemistry.

As has been the custom, the Division of Chemical Education will attempt to provide at nominal cost lodging for all graduate and undergraduate students of chemistry who attend the meeting. Requests for accommodations should be directed to Professor C. E. Boord, Department of Chemistry, The Ohio State University, Columbus, Ohio.

Light Fan to Guide Aviators to Safe Landings. Rotating fans of vari-colored light such as will guide future aviators to safe landings at night are now in operation at the Cleveland municipal airport. The airport beacon by rotating reaches the pilot at any angle at which he may approach the field. Half of the beam is white and half red, producing alternate flashes to distinguish the beacon from the brilliant lighting of parks, railroad yards, or streets. High candlepower is used in order that light may penetrate fog as effectively as possible. Color is produced by special cover glasses placed over the incandescent lamp projectors.—*Science Service*

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS OF THE JOURNAL OF CHEMICAL EDUCATION

NOVEMBER 21, 1927, TO DECEMBER 31, 1928

Balance taken over November 21, 1927, from Erle M. Billings, Business Manager, Educational Division, American Chemical Society				$1,013.41
RECEIPTS:				
Contributions from The Chemical Foundation, Inc.			$21,000.00	
Subscriptions			19,667.82	
Advertising			8,345.98	
Reprints			611.31	
Service Department—Net			89.51	49,714.62
				$50,728.03
DISBURSEMENTS:				
JOURNAL Cost:				
Printing JOURNAL		$24,595.85		
Editorial Expense:				
Salaries:				
Mildred Grafflin	$2,466.65			
Otto Reinmuth	2,208.38			
M. A. Cartwright	750.00			
Neil E. Gordon	750.00			
Marguerite Little	390.00			
Abstractors' Fees	341.73			
Traveling Expense	1,490.09			
Stationery and Office Supplies	414.51			
Miscellaneous	500.67	9,312.03	$33,907.88	
Sundry Expenses Incurred Prior to December 1, 1927			8,823.14	
Circulation Expenses—Miscellaneous, Printing, Postage, Advertising, etc.			3,655.42	
Furniture and Fixtures—Desks, Typewriter, Files, etc.			554.90	
Printing Reprints			1,234.30	
Telephone and Telegraph			102.91	
Stationery and Office Supplies			260.71	
Postage			539.68	
Insurance—On Life of Dr. Gordon			279.75	
Miscellaneous			244.35	49,603.04
BALANCE IN BANK AND ON HAND, DECEMBER 31, 1928				$1,124.99

We hereby certify that the above Statement of Cash Receipts and Disbursements is in accordance with the books of the JOURNAL OF CHEMICAL EDUCATION for the period November 21, 1927, to December 31, 1928.

(Signed) PASLEY AND CONROY,
Certified Public Accountants

Dated: January 18, 1929

The Chemistry Student

THE STRUCTURE OF MATTER. VII. APPLICATION OF THE ELECTRONIC THEORY TO OXIDATION-REDUCTION

OTTO REINMUTH, ASSOCIATE EDITOR

In previous articles of this series, we have outlined those features of the theory of atomic structure which seem to be at the same time most widely acceptable to chemists in general, and most necessary to a truly scientific explanation of the facts ordinarily encountered in the study of general chemistry. We have discussed chemical combination and valence in terms of our theory of atomic structure and have considered the relationship between the structures of elements and their chemical properties as indicated by the periodic system. We have also made note of the electrical effects connected with certain chemical reactions, as exemplified in the process of electrolysis and in the operation of the concentration and the two-metal cells. Let us now turn our attention to the consideration of one of the most important types of chemical reaction—oxidation-reduction.

The Nature of Oxidation-Reduction

Years ago it was customary to define or explain oxidation-reduction in terms of gain or loss of oxygen or its equivalent. To quote from an old edition of Professor Mellor's "Modern Inorganic Chemistry" (1918):

> . . . The word "oxidation" connotates the process of combination of oxygen with an element or compound; and "reduction," the reverse operation, namely, the withdrawal of oxygen from an oxy-compound. . . The ideas associated with oxidation and reduction have been extended to include elements other than oxygen. For instance, the transformation of mercuric chloride, $HgCl_2$, to mercurous chloride, HgCl,[1] and finally to mercury by the action of stannous chloride, $SnCl_2$, are processes of reduction. The stannous chloride is at the same time oxidized to stannic chloride, $SnCl_4$, thus:
>
> $$SnCl_2 + 2HgCl_2 = SnCl_4 + 2HgCl$$
>
> The two operations—oxidation and reduction—are reciprocal in that the oxidizing agent is reduced and the reducing agent is oxidized by the process. . . Similarly the removal or addition of hydrogen is styled a process of oxidation or of reduction, respectively. . .

This sort of definition served the experienced chemist very well for most practical purposes, but it was usually rather confusing to the beginner. The latter found it difficult to see why the addition of chlorine to a com-

[1] According to the best present practice, mercurous chloride should be written Hg_2Cl_2. All experimental evidence supports this formula and indicates that the mercurous ion is really Hg_2^{++} rather than Hg^+.

pound such as $FeCl_2$ to form $FeCl_3$ should be called "oxidation." He was bound to wonder also why, if the addition of chlorine or oxygen constituted "oxidation," the addition of hydrogen should constitute the opposite of oxidation, *i. e.*, "reduction."

A somewhat less confusing definition was that which described the oxidation of an element as an increase in its positive valence or a decrease in its negative valence. In these terms, reduction consists, of course, in a decrease in positive valence or an increase in negative valence.

In the light of our present knowledge of atomic structure, we are prepared to go farther and to define these processes more fundamentally. A little reflection brings us to the conclusion that changes which are usually classed as oxidations involve the loss of electrons, whereas reductions involve the gain of electrons. Upon this basis the reason why oxidation and reduction should be reciprocal and inter-dependent processes is obvious. When we say that the oxidation of one substance must invariably be accompanied by the reduction of some other substance or vice versa, we are merely asserting a special case of the general axiom that matter can neither be created nor destroyed, for we are only saying in effect that when one substance gains electrons, it must gain them from some other substance which gives them up. Thus, while we may speak of the oxidation of one substance or the reduction of another substance, the reaction as a whole is always an *oxidation-reduction* reaction.

With reference to any one reaction it is customary and entirely correct to speak of the substance which is oxidized as the *reducing agent* and the substance which is reduced as the *oxidizing agent.* It is well to note, however, that, when generally applied, the terms "oxidizing agent" or "reducing agent" are only relative in meaning. Compounds or elements which are able to take electrons from a relatively large number of other compounds or elements are in general good oxidizing agents; those which give up electrons to a relatively large number of other substances are in general good reducing agents. Substances which can either gain or lose electrons play the part of reducing agents in some reactions and of oxidizing agents in others, depending upon the tendency of some other reactant present to gain or lose electrons.

Oxidation-Reduction and the Electromotive Series

Since oxidation-reduction is essentially a transference of electrons, and since the possibility of electron transfer depends upon the varying degrees of attraction for electrons exhibited by different elements, it is evident that the electromotive series which we discussed briefly in December[2] has a close relationship to the subject under consideration. On page 1645 of our December article appeared an abridged electromotive table which included

[2] THIS JOURNAL, **5**, 1039–46 (Dec., 1928).

only a few of the commoner elements. Those elements at the top of the table have but a slight attraction for electrons; those at the bottom attract electrons very strongly.

Let us consider a well-known demonstration experiment[3] in the light of the facts set forth by the table. We observe that, of the three halogens—chlorine, bromine, and iodine—chlorine stands lowest in the table, bromine next, and iodine highest. In any competition for electrons among these three elements, therefore, we would bet on chlorine to win, with bromine to place, and iodine to show. The experiment mentioned supports our judgment for we find that gaseous chlorine displaces bromine from a bromide in solution and that bromine, in turn, displaces iodine from an iodide in solution. The essential part of the first of these reactions may be described by saying that elementary chlorine takes electrons away from bromine ions, so that ionic chlorine is formed and elementary bromine is liberated. These facts may be expressed in the following partial equations:

$$Cl_2^\circ + 2\epsilon \longrightarrow 2Cl^-$$
$$2Br^- - 2\epsilon \longrightarrow Br_2^\circ$$

Adding these partial equations algebraically we obtain:

$$Cl_2^\circ + 2Br^- \longrightarrow 2Cl^- + Br_2^\circ$$

It is evident that elementary chlorine has acted as an oxidizing agent (having gained electrons), and that bromine ions have been oxidized.

The second reaction may be summed up as follows:

$$\begin{array}{r} Br_2^\circ + 2\epsilon \longrightarrow 2Br^- \\ 2I^- - 2\epsilon \longrightarrow I_2^\circ \\ \hline Br_2^\circ + 2I^- \longrightarrow 2Br^- + I_2^\circ \end{array}$$

Here elementary bromine has acted as an oxidizing agent by taking electrons away from iodine ions.

If we had extended our apparatus and constructed it of suitable material,[4] we might have begun by displacing chlorine from a chloride solution by means of fluorine, a halogen which stands still lower in the electromotive table. The reaction involved would have been entirely analogous to those just outlined, namely:

$$\begin{array}{r} F_2^\circ + 2\epsilon \longrightarrow 2F^- \\ 2Cl^- - 2\epsilon \longrightarrow Cl_2^\circ \\ \hline F_2^\circ + 2Cl^- \longrightarrow 2F^- + Cl_2^\circ \end{array}$$

[3] For a detailed description of the experiment see: Raymond Szymanowitz, "Demonstration Apparatus for the Simultaneous Preparation of the Halogens," THIS JOURNAL, **2**, 440–1 (June, 1925).

[4] To avoid the destructive action of fluorine on glass.

Experiments like the one we have just described furnish a qualitative measure of the electronegativities[5] of various elements. A quantitative evaluation could be achieved if we were able to measure the difference in charge which exists between a pole composed of the element, and a solution containing a definite concentration[6] of the ions of that element. Such an arrangement would constitute a half-cell like the Zn, Zn^{++}, and Cu, Cu^{++} half-cells which we discussed in January.[7] There is no accurate means of measuring such a difference in charge but we can connect two such half-cells and measure the difference in potential between them in volts. If we arbitrarily select some one half-cell as a standard and measure all others against it,[8] we can determine a series of voltages which are quantitatively (though arbitrarily) representative of the electronegativities of the various elements and ions involved. The reader may wonder how it is possible to prepare a gaseous electrode. It has been found, however, that a platinum electrode coated with spongy platinum and then saturated with the gas to be investigated acts in all respects as though it were an electrode of the pure gas.

In the table[9] here reproduced, the H_2, H^+ half-cell is chosen as a standard, and the voltages represent the differences in potential between that half-cell and the others listed. The sign given the voltage is a convention arbitrarily determined by the order in which the members of the respective cells are written. It is immaterial which order is selected if that order is consistently maintained throughout.

A convenient rule for the use of Table I states that if any two equilibria are written in the order of algebraically decreasing potentials, the arrows indicating the course of the reaction will point in *clockwise* directions. This sounds rather foggy at first but an illustration or two will make it clear. Suppose we desire to know whether or not ferric ion is reduced by

[5] It will be recalled that we have defined the "electronegativity" of an element as the degree of its attraction for electrons.

[6] For the benefit of teachers who may read these articles, be it said that we realize the inaccuracy of the word "concentration" in this connection. We feel, however, that nothing but confusion could result from any attempt to introduce the concept of activity in an article of this nature.

[7] THIS JOURNAL, **6**, 117–22 (Jan., 1929).

[8] In practice it is not necessary that the half-cell to be determined be measured directly against the half-cell chosen as a standard of reference. It may be measured against some other half-cell and reference made to the standard by calculation. Advanced students are recommended to see Lewis and Randall, "Thermodynamics," McGraw-Hill, **1923,** Chapter XXX, for a description of the experimental means employed to overcome practical difficulties in the determination of a number of standard electrode potentials.

[9] The table is compiled from values tabulated by Lewis and Randall, "Thermodynamics," McGraw-Hill, **1923,** p. 433, and Cartledge, "Introductory Theoretical Chemistry," Ginn and Co., **1929,** p. 426. See also Gerke, *Chem. Rev.*, **1**, 377 (1925).

TABLE I—SINGLE ELECTRODE POTENTIALS OF THE ELEMENTS AT 25°C.[10]

Reduced state	Oxidized state	Electrode potential in volts	Reduced state	Oxidized state	Electrode potential in volts
Li	Li^+	+2.9578	H_2	H^+	±0.00
Rb	Rb^+	+2.9242	(Sb)	(Sb^{+++})	(−0.1)
K	K^+	+2.9224	(Sn^{++})	(Sn^{++++})	(−0.14)
Na	Na^+	+2.7125	Bi	Bi^{+++}	−0.20
Zn	Zn^{++}	+0.7581	Cu	Cu^{++}	−0.3448
S^{--}	S(rh.)	+0.51	OH^-	$O_2 + H_2O$	−0.3976
Fe	Fe^{++}	+0.441	I^-	$I_2(s)$	−0.5357
Cd	Cd^{++}	+0.3976	Fe^{++}	Fe^{+++}	−0.75
Tl	Tl^+	+0.3363	Hg	$^1/_2(Hg_2)^{++}$	−0.7986
Co	Co^{++}	+0.24	Ag	Ag^+	−0.7995
Sn	Sn^{++}	+0.136	$^1/_2(Hg_2)^{++}$	Hg^{++}	−0.92
Pb	Pb^{++}	+0.122	Br^-	$Br_2(l)$	−1.0659
Fe	Fe^{+++}	+0.045	Cl^-	$Cl_2(g)$	−1.3594
H_2	H^+	±0.00	Co^{++}	Co^{+++}	−1.82

iodide ion. Reference to the table shows that the I^-, I_2 equilibrium gives a potential of —0.5357 and that the Fe^{++}, Fe^{+++} equilibrium gives —0.75. Since —0.5357 is algebraically greater than —0.75, we write the *iodide, iodine* equilibrium first, using an arrow which points to the right (for at the top of the face the hands of the clock move from left to right). Underneath we write the *ferrous, ferric* equilibrium, using an arrow which points to the left (since at the bottom of the face the clock hands move from right to left).

$$I^- \longrightarrow I_2 \qquad -0.5357$$
$$Fe^{++} \longleftarrow Fe^{+++} \qquad -0.75$$

Our diagram indicates that ferric ion, Fe^{+++}, is reduced to ferrous ion, Fe^{++}, by iodide ion, I^-, and experiment verifies that statement.

If, however, we consider chloride ion instead of iodide ion, we find that our diagram must be set down as follows:

$$Fe^{++} \longrightarrow Fe^{+++} \qquad -0.75$$
$$Cl^- \longleftarrow Cl\ (g) \qquad -1.3594$$

indicating that chloride ion cannot reduce ferric ion to ferrous ion but that chlorine oxidizes ferrous ion to ferric ion.

The rule as stated is empirical and therefore has the virtue of convenience rather than of scientific clarity. However, a little study will show the student that when all the conditions necessary for the application of the rule are taken into account, the scientific reasons underlying it become clear.

[10] Ions at unit activity. Partial pressures = 1 atmosphere. Sign gives "charge on solution."

The student should bear in mind the fact that the potentials given in the table are based upon definite effective concentrations of the ions involved. The establishment of conditions which result in the removal or suppression of one ion involved in an equilibrium will change the equilibrium point and can in some cases reverse the course of the reaction. Thus, in the case of the *ferrous, ferric-iodide, iodine* equilibrium, we find that the $[Fe^{+++}]/[Fe^{++}]$ ratio can be reduced to such a low value that iodine will oxidize ferrous ion. One means of doing this is to add oxalic acid which removes ferric ion by uniting with it to form a complex ion:

$$Fe^{+++} + 3C_2O_4^{--} \longrightarrow Fe(C_2O_4)_3^{---}$$

It is seldom that the student of general chemistry need concern himself with such complications. He will deal with them in much more detail than we can afford space for here when he takes up the study of physical chemistry.

There is one case of a similar nature which the student of general chemistry does encounter, however, and which it might be well to consider here. That is the solution of gold in *aqua regia*. We have already noted that metals cannot enter solution except in the ionic form.[11] The solution of metallic gold must therefore involve the oxidation of elementary gold to ionic gold. Let us first inquire why nitric acid alone cannot effect this oxidation.

We have not included electrode potential values for the transitions which involve the oxidation of Au to Au^{+++} ion, nor the reduction of NO_3^- ion to $NO_2 + H_2O$, for the reason that values comparable in accuracy to the others listed are not available. However, we know that the value for Au, Au^{+++} is very close to that for Cl^-, Cl_2 and is usually tabulated just below it. NO_3^- ion on the other hand is a considerably weaker oxidizing agent than Cl_2. On this basis we would not expect NO_3^- ion to oxidize Au at all.

It must be remembered, however, that we have been dealing all along with equilibria and that the reactions which we have considered have all been reversible to some extent. The arrows which we have employed should be taken to mean that the equilibrium normally lies very far in the direction indicated by the single arrow. Nevertheless, to be strictly correct, we must write these reactions reversibly with a double arrow. Hence, it follows that NO_3^- ion is able to oxidize a very minute amount of metallic gold to Au^{+++} ion. The Au^{+++} ion, however, has such a strong attraction for electrons that equilibrium is reached before the concentration of Au^{+++} becomes appreciable by any ordinary means. The case is analogous to that which we discussed with relation to the solution of Zn^{++} ions in the

[11] No doubt solutions of metal in metal are exceptions to this statement, but for the purpose of the present exposition we shall allow it to stand.

zinc half-cell.[12] In order to displace the equilibrium point and so cause the reaction to proceed in the direction desired we must remove Au^{+++} ions as fast as they are formed. We can do so by supplying Cl^- ions which unite with the Au^{+++} ions to form complex $(AuCl_4)^-$ ions. That is the function of the HCl in the *aqua regia* mixture.

We may write the partial equations involved as follows:

$$(1)\quad 3NO_3^- + 6H^+ + 3\epsilon \rightleftharpoons 3NO_2 + 3H_2O$$
$$(2)\quad Au^\circ - 3\epsilon \rightleftharpoons Au^{+++}$$
$$(3)\quad Au^{+++} + 4Cl^- \rightleftharpoons (AuCl_4)^-$$

The equilibrium represented by equation (3) lies so far toward the right that we are justified in writing the reaction:

$$Au^{+++} + 4Cl^- \longrightarrow (AuCl_4)^-$$

Assembling our partial equations and eliminating repeated terms we have:

$$Au^\circ + 4Cl^- + 3NO_3^- + 6H^+ \longrightarrow (AuCl_4)^- + 3NO_2 + 3H_2O$$

If we desire to convert this equation into the customary molecular form we can easily do so:

$$Au + 4HCl + 3HNO_3 \longrightarrow HAuCl_4 + 3NO_2 + 3H_2O$$

Balancing Ionic Oxidation-Reduction Equations

It is evident from what we have said thus far that the only rational basis for a consideration of ionic oxidation-reduction reactions lies in the electronic changes involved. There are several methods of applying the electronic concept to the balancing of oxidation-reduction equations.[13] On the whole, the present writer prefers that described by Professors Jette and La Mer.[14] The equations which we have just employed for the reaction between gold and *aqua regia* are in accordance with their system. The reader will note that this method of treatment deals only with those components which actually undergo change in the course of the reaction. When the equation has been balanced electronically, it is a simple matter to make the additions necessary to produce a molecular equation if that is desired.

The rules given by Jette and La Mer are as follows:

[12] See THIS JOURNAL, **6**, 117–22 (Jan., 1929), especially pp. 117–9.

[13] See, for instance: H. L. Lochte, "The Pole Reaction Method of Teaching Oxidation and Reduction Reactions," *Ibid.*, **4**, 223–7 (Feb., 1927); W. M. Hoskins, "The Use of the Equivalent System in Chemical Calculations," *Ibid.*, **4**, 1013–20 (Aug., 1927); also Wm. T. Hall, this number, pp. 479–85.

[14] E. R. Jette and V. K. La Mer, "The Balancing of Oxidation-Reduction Equations. I and II," *Ibid.*, **4**, 1021–30 (Aug., 1927); 1158–67 (Sept., 1927).

Rule 1. Ascertain the products of the reaction; without this knowledge any attempt at balancing the equation is utterly useless.

Rule 2. Set up a partial equation for the oxidizing agent.

Rule 3. Set up a partial equation for the reducing agent in the same way.

Rule 4. Balance each of the partial equations electrically.

Rule 5. Multiply each partial equation by a factor so that when the two are added, the electrons just compensate each other.

Rule 6. Now add the two partials. The result is the final *ionic equation* for the reaction. In some cases. . . it will be possible to simplify the equation by cancelling out certain substances which appear on both sides of the equation.

By way of example let us consider the reaction between potassium permanganate and sodium sulfite in acid solution.[15] The significant reactants are: permanganate ions, hydrogen ions, sulfite ions, and water. The products of the reaction are manganous ions, sulfate ions, hydrogen ions, and water.

Applying *Rule 2* we write:

$$MnO_4^- + 8H^+ \longrightarrow Mn^{++} + 4H_2O$$

Rule 3:

$$SO_3^= + H_2O \longrightarrow SO_4^= + 2H^+$$

Balancing the partial equations electrically according to *Rule 4*,

$$(1)\quad MnO_4^- + 8H^+ + 5\epsilon \longrightarrow Mn^{++} + 4H_2O$$
$$(2)\quad SO_3^= + H_2O - 2\epsilon \longrightarrow SO_4^= + 2H^+$$

Applying *Rule 5*,

$$(1)\quad 2MnO_4^- + 16H^+ + 10\epsilon \longrightarrow 2Mn^{++} + 8H_2O$$
$$(2)\quad 5SO_3^= + 5H_2O - 10\epsilon \longrightarrow 5SO_4^= + 10H^+$$

Adding the two partials in accordance with *Rule 6*,

$$2MnO_4^- + 16H^+ + 5SO_3^= + 5H_2O \longrightarrow 2Mn^{++} + 8H_2O + 5SO_4^= + 10H^+$$

Cancelling substances which appear on both sides of the equation,

$$2MnO_4^- + 6H^+ + 5SO_3^= \longrightarrow 2Mn^{++} + 3H_2O + 5SO_4^=$$

Oxidation-Reduction Cells

No doubt the reader has already realized that the action of the zinc-copper cell which we have discussed previously[4] is essentially a process of oxidation-reduction. The type of cell often referred to as the oxidation-reduction cell, however, is that in which the electrodes are unattacked[16]

[15] The reaction would take a different course in alkaline solution.

[16] Platinum electrodes are usually employed to achieve this condition. Carbon is also a possibility.

and in which oxidation of some substance in solution takes place at one pole and reduction of some other substance in solution takes place at the other pole. Almost any oxidation-reduction reaction can be carried on by placing a solution of the reducing agent in one vessel and a solution of the oxidizing agent in another vessel and permitting a current to flow by connecting the vessels by means of a salt bridge and a pair of connected electrodes. For this reason, partial equations such as those which we have just employed are sometimes called *pole reaction equations*. One partial equation describes the action taking place at the oxidizing pole; the other describes the reaction taking place at the reducing pole.

It is evident that any distinction between so-called oxidation-reduction cells and cells of the Daniell type is artificial and based upon convention rather than upon the fundamental characteristics of the respective systems.

Solvent Extraction of Oil from Seeds. Although the process of solvent extraction has been known and in use for very many years, it is comparatively recently that its extended use has been developed in the vegetable oil industry, as an alternative to the expression of the oil from seeds by hydraulic pressure. All classes of oil seeds can be treated effectively by the solvent process, and both the oil and the residue can be guaranteed entirely free from any trace of the solvents used. Rose Downs and Thompson, Ltd., of Hull, well known as makers of solvent extraction plant, have sent us a pamphlet dealing with the subject in which it is pointed out that the primary advantage offered by the solvent process is that, instead of leaving from 5 to 10 per cent of oil in the residue, practically the whole of the oil can be removed from the seed. The residue from the solvent process is as little as $^1/_2$ per cent, and although it is possible to extract all the oil, this latter procedure is not usually commercially economic.

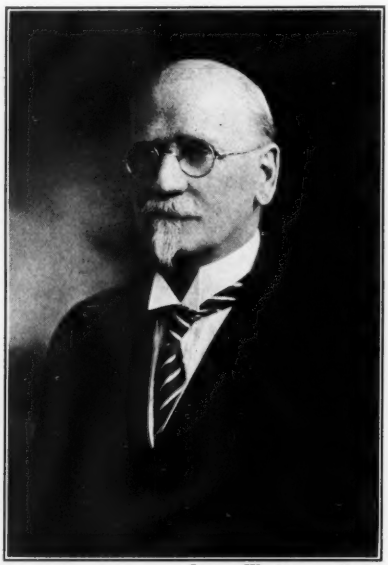
The theory of solvent extraction is that when ground oleaginous seed is saturated with some suitable chemical solvent, the oil is dissolved by the solvent and can be drained off with it. The mixture is subjected to heat to evaporate the solvent, the vapor of which is condensed and used again. Benzine is the solvent chiefly employed in the vegetable oil industry. The process, briefly explained, consists of the following operations: after the preliminary preparation of the seed, the solvent is allowed to percolate the ground seed in an enclosed pan. The mixture of oil and solvent is drained into an evaporator, and the solvent driven off by heat, passing as vapor to condensers, where it liquefies. The residue in the form of meal is treated with steam to remove any remaining solvent, which is also condensed.

Rose Downs and Thompson, Ltd., have designed numerous large solvent extraction plants at work on vegetable oils in this country, for dealing with quantities up to 1200 tons a week and are in a position to advise as to what plant will function best in given circumstances; since it is obviously impossible to have a standard universal plant. In some instances a combination of pressing and solvent plants is employed, as, for example, to treat castor seed when a high quality medicinal oil is required. For this purpose, the medicinal oil is expressed by cold pressing in one of their "Premier" or cage type presses. The cakes from this first pressing are then broken up, and further treated in a solvent extracting plant, which extracts practically the whole of the remaining oil, less than 1 per cent usually being left in the residue.—*Chem. Age*, **20**, 112 (Feb. 2, 1929).

WHAT THE CHEMISTRY STUDENT SHOULD KNOW ABOUT PATENT PROCEDURE. II. ORGANIZATION OF THE PATENT OFFICE

LLOYD VAN DOREN, WARFIELD & WATSON, 247 PARK AVENUE, NEW YORK CITY

The passage of the Act of 1836, with which our present series of numbering began, marked a new era in the procedure by which patents were granted. Prior to that time there was practically no examination. But patents had been granted long before the Revolutionary War in Massachusetts and Connecticut under the old British system, and they were there granted by the respective legislative bodies following a conference with the inventor.



Lettau, Washington, D. C.

HON. THOMAS E. ROBERTSON, COMMISSIONER OF PATENTS

The Act of 1790 attempted, in a measure, to ascertain the utility and state of the art, but these efforts were far from all that might be desired.

The institution of the examination system was in marked contrast to the previously existing registration method and there were provided at this time the facilities and organization to initiate and carry on this type of system which entailed an examination and determination of the utility, novelty, and patentability of an alleged invention. There was provided also the means for collecting the art, both patent and publication, and a personnel properly trained to examine the applications intelligently, and the machinery and procedure for giving effect to the purpose of the law. In other words, there was placed upon the Patent Office the burden which the courts had previously performed, in order, as it has been stated, "to eliminate litigation before it begins."

The procedure provided for in the Act of 1836 gave to the grant of a patent the standing of *prima facie* validity. Since 1836 more than 1,700,000 patents have been granted.

At the beginning, the Patent Office personnel consisted of a commissioner of patents, one examiner, and three clerks, two of whom should be qualified

draftsmen. At the present time, the personnel includes a commissioner, two assistant commissioners, a solicitor, five law examiners, a board of appeals of five members, sixty-two primary or principal examiners, something over five hundred assistant examiners, and a clerical force of over six hundred. Each of the primary or principal examiners is in charge of an examining division in which a certain definite art is examined, and each principal has under him perhaps eight to ten assistant examiners.

The sixty-two divisions in their art represent the whole realm of human endeavor; and whether the invention is for a hair pin or a cantilever bridge; a perfume, a dyestuff, or a deadly gas; a process for mounting jewels or for extracting and refining metals; a new toy or a new sixteen-inch naval gun; be it a mechanical, a chemical, or an electrical invention; be it as simple as a pin or as complex as a newspaper printing press or an adding machine, there is among the corps in the Patent Office one who has the expert knowledge necessary to understand the invention, its operation, and the field covered by similar attempts.

It is required that all material devices, operations, and processes, and every development pertaining thereto, must come before the examining force of the Patent Office for critical scrutiny before being protected by a patent. It may be rejected or objected to and in view thereof amended and finally accepted; or it may be accepted at once, although this is rather the exception than the rule.

In order to become a member of the examining corps of the Patent Office, one must pass a civil-service examination, and this examination is of such nature that nearly all the members of the corps have college degrees. Many of them hold degrees not only in arts or sciences but in law as well, as it has been found that such a combination is highly desirable for proper conduct of the duties which fall to them.

It is necessary for the assistant examiner, who must pass on the questions of utility, novelty, and patentability, to know the "art," that is, patents and literature, foreign and domestic, relating to the invention described. Accordingly, he must be familiar with the patents and publications in various languages covering the particular field of invention. He must have full knowledge of the principles in accordance with which the inventions which he is examining operate, and must have knowledge of related or analogous inventions throughout the Patent Office.

The assistant examiners are in correspondence with the attorneys representing the largest manufacturing and industrial interests in this country and abroad, and they must therefore be so familiar with the principles and decisions of patent law as to be able to carry on such correspondence and to maintain their end of the controversy.

The principal examiners, or heads of various divisions, are the superiors of the assistant examiners. They have charge of the various classes

of inventions being examined in their division and it is their decision, whether favorable or otherwise with respect to the application, which is final. It has been estimated that these decisions of the principal examiners involve property rights which run into many millions of dollars annually. As examples, reference may be made to such outstanding inventions as that of Hall for the winning of aluminum; Goodyear for the vulcanization of rubber; Baekeland for the manufacture of bakelite; Acheson for the manufacture of graphite; Hyatt for the manufacture of celluloid; Edison for the incandescent lamp; Just and Hanaman for tungsten filaments; Langmuir for the nitrogen-filled incandescent bulb; De Forrest for radio; and the list could be extended almost indefinitely. It, however, should not be gathered from this that all of the applications which mature into patents are valuable and reap a fortune for their inventors. The percentage of such applications is quite small.

Other than the examining and clerical staffs above referred to, the organization of the Patent Office includes two interference examiners, one with reference to patents, the other with reference to trade-marks, a trade-mark examiner, and a classification examiner. The examiners of interference pass upon the question as to who is the earlier inventor when it appears that the claims of two inventors are directed to the same invention.

The classification examiner has in his charge what is perhaps the most complicated work in the Patent Office. We have seen that 1,700,000 patents have been granted. These patents must all be classified properly with respect to the art to which they pertain, as obviously, otherwise, it would be impossible for any examiner to make anything like a real examination in the art. In this 1,700,000 patents there are several million facts disclosed, each one more or less concrete and all more or less associated in various combinations, which combinations involve several more million arrangements of a greater or lesser number of units. The importance of a real scientific classification of the millions of facts disclosed in the patents will be quite evident when it is realized that the effectiveness of the examiner's search is entirely dependent on the thoroughness and character of this classification. This work has been going on for more than twenty years and has cost considerably more than half a million dollars, and while as yet it is not wholly complete, nevertheless the system is at present a most workable one and eventually completeness will be secured[1].

Of the sixty-two examining divisions, there are perhaps ten of these divisions in which applications relating to chemistry are examined. These divisions are the following, being known by numbers: 2, 3, 6, 15, 31, 43, 50, 55, 56, and 59. In the belief that the types of inventions which are examined in the aforementioned divisions will be of interest, there is given herewith the various classes examinable in these divisions. Not all of these

[1] Wyman, *J. Pat. Office Soc.*, **9**, 71 (1926–27).

divisions are wholly chemical; however, it may quite properly be said that divisions 6, 31, and 59 are wholly chemical.

Division 2: examines inventions pertaining to bee culture; dairy; preserving; presses; tobacco.

Division 3: heating; metal founding; metallurgy; metal treatment.

Division 6: carbon chemistry; dyeing; explosives; sugar and starch.

Division 15: glass; plastic block and earthenware apparatus; plastics.

Division 31: ammonia, water, and wood distillation; charcoal and coke; gas, heating and illuminating; mineral oils.

Division 43: baths, closets, sinks, and spittoons; sewerage; electricity, medical and surgical; medicines; surgery; dentistry; artificial body members.

Division 50: plastic and liquid coating compositions; coating.

Division 55: bread, pastry, and confection making; cutlery; designs.

Division 56: electrochemistry; laminated fabrics; paper making; substance preparation.

Division 59: chemistry; alcohol; fertilizers; oils, fats, and glue; cement and lime; hides, skins, and leather; fuel.

When an application pertaining to an invention is received by the Patent Office, it is given a cursory examination to determine the art to which it relates and then is referred to the division in which that art is examined. For example, a process which has to do with the manufacture of alcohol would be referred to *Division 59* for examination, whereas a process having to do with the manufacture of a dyestuff, say of the alizarine type, would be referred to *Division 6* for examination, and so on.

It may not be amiss to include at this point a list of books which will be found suitable for correlated reading.

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Protecting Foundations against Acid Attack. While the ordinary concrete floor is long-lived and wear-resisting in most types of factory, it is readily susceptible to chemical attack and disintegration when used in places where there is constant exposure to acid. Thus the foundations of a building may also be attacked in time. A type of flooring is needed which can resist unavoidable spilling of acid and can also withstand heavy loads and hard wear. Such properties are claimed for Prodorite, a compound for flooring, which has remarkable resistance to acid attack. It has, according to a National Physics Laboratory report, a crushing strength of 6000 lb. per sq. inch, and possesses a resistance to abrasion double that of matured 2:1 sand-Portland cement concrete. At 60°C. the material is stated to withstand concentrated hydrochloric acid, 65 per cent sulfuric acid, and 15 per cent nitric acid. It also resists the above acids in the cold at greater concentration. A Prodorite floor is composed of precast slabs bedded in Prodorite compound, the whole being supported on a concrete base. It may be used immediately after laying. Among users of this material are manufacturers of chemicals, dyes, artificial silk, margarine, cider and spirits, tanneries, breweries, galvanizers, laboratories, sewage undertakings and dairies, a range wide enough to show the many uses to which this type of flooring may be put.—*Chem. Age*, **19,** 395 (Oct. 27, 1928).

Australia and U. S. Exchange Insect Pest War Information. The strategy used in the United States in warfare against crop-devouring insects will find application in Australia, as the result of the visit of W. B. Gurney, government entomologist of New South Wales, in America, following the Fourth International Congress of Entomology at Ithaca, N. Y., last summer.

Mr. Gurney has visited experiment stations in a number of the western states, whose agricultural and horticultural problems are more or less similar to those of New South Wales. In Utah he found that the poisons used against the alfalfa caterpillar were like those employed in Australia, but that the American farmers were finding it possible to use a much higher concentration than had hitherto been considered safe in Australian practice. Western American attacks on the grasshopper plague also yielded useful information.

The Australian entomologist found citrus growers at the Riverside Experiment Station in California using Australian parasitic insects in their campaign against the mealybug. It is expected that these parasites will save California orchardists many thousands of dollars annually if they can be thoroughly established in their new home.—*Science Service*

TEXTILES AND TEST TUBES.* PART III

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Rayon through the Microscope

Rayon (with the possible exception of Bemberg) can readily be distinguished from silk by means of the microscope because of the fact that the fibers are larger and present a peculiar texture of outline with which one becomes familiar by careful study. The Bemberg fiber is so fine that it requires considerable practice to be able to distinguish it microscopically. Cross-section views reveal the fact that the fibers are not quite as regular as they appear when looked at longitudinally. These irregularities occur as the liquid is squeezed out through the orifices of the spinneret. These do not interfere with the luster of the fiber, however, since the fibers still present an excellent mirror-like surface for the reflection of light rays in parallel lines.

Identifying Rayon Chemically

The following simple qualitative procedure, based either on comparative solubilities, or upon comparative dyeing qualities will form a satisfactory method of distinguishing the four types of rayon chemically:

Reagent	Viscose	Tubize	Bemberg	Celanese
Acetone	no change	no change	no change	dissolves
1% Carminic acid. Allow fibers to remain in soln. 5 min., then dip in distilled water	pink	deep pink	no change or slightly colored	no change
Ruthenium red 0.1 g. in 10 cc. water	pink	red-violet	light blue	yellow

New Wrinkles in the Rayon Industry

Hollow rayon fibers have recently been produced by application of sodium carbonate, or a similar substance, to the digested liquor. This generates carbon dioxide when the filament hits the acid-hardening bath, which causes the production of a channel through the tube. This hollow tube will then collapse somewhat into a ribbon-like fiber, which has increased elasticity and improved drying qualities because of the in-

* This article is an elaborated revision of a paper read before the Institute of Chemistry at State College, Pennsylvania, July 26, 1927. The original paper was published in the *Chemistry Leaflet*, **1**, No. 14 (Jan. 14, 1928).

crease in interior and exterior surface. La Compagnie Nouvelle des Applications de la Cellulose, of Gouchy, France, is marketing a tubular fiber made with bubbles, under the trade name of *Celta*.

Among other new developments in the rayon industry, we find the introduction of delusterized rayon. No sooner had the human race produced a fiber that surpassed all previous fibers in luster, than a clamor was set up to remove some of the luster. This has been done, and lusterless rayon (produced by precipitating barium sulfate or some other similar compound in the fiber) is on the market. Another new wrinkle in rayon manufacture is the production of immunized rayon. Immunized rayon can be made in such a way that it is immune to all dyes, or it can be made to resist some dyes and take on others. This product is being used with non-immunized rayon in the production of fancy two- or three-color patterns on fabrics.

The modern tendency in rayon manufacture is toward the production of threads with a larger number of fibers per thread. Ordinarily 24 filaments are combined together and twisted into one thread. The modern so-called super extra yarns have 60 or more filaments in the thread. This gives a softer, finer appearing thread with an excellent covering power and a more subdued sheen.

Cornstalks and Cane

A few years ago attention began to be drawn to the advisability of finding out how to utilize farm wastes as a means of helping to improve the status of agriculture in this country. Congress appropriated $50,000 for research in this field, and designated the Bureau of Standards as the agency for carrying out this program. Dr. Warren E. Emley, Chief of the Organic and Fibrous Materials Division of the Bureau, entered into a coöperative agreement with Iowa State College, at Ames, whereby the Chemical Engineering Laboratory at this college (under the direction of Professor O. R. Sweeney) should conduct a piece of research on the utilization of cornstalks.

The first work done at Ames has been the production of an insulating and building board from the cellulose fibers of cornstalks. Boards suitable for serving as the raw material in the rayon and other cellulose industries will be worked on in their turn in this laboratory.

An Indiana Company has already been capitalized for the exploitation of the cellulose of cornstalks. Rayon is the chief product which the members of this company hope to make when they pass from an experimental to a commercial basis.

A German syndicate proposes to establish a rayon plant in Jamaica which will attempt to develop a process for the utilization of fibers from waste cane, as a raw material for their industry.

The Natural and the Synthetic Combined

One of the chief uses of rayon is in combination with other fibers. Rayon has really been an inspiration to the cotton goods manufacturer. It has enabled him to create many new designs and new patterns by combining rayon with his less interesting cotton fabrics. Rayon has been artistically combined with wool in "silvertone" and striped materials, and with silk in many novelty cloths. Silk-plated rayon hose, in which silk is superimposed on rayon gives one of the sheerest kinds of hosiery to be desired. Far from being a competitor of silk, rayon has rather worked out a new field for itself and is no longer called or looked upon as "artificial silk."

Hot Dogs and Hats

The production of synthetic clothing has not been restricted to the human race. Hot dogs, once trimly clad in shirts made of intestines, are now more conveniently dressed in tight-fitting jackets of Visking, a synthetic cellulose product. A recent practice in this connection is to encase sausage and "weenies" in Visking coverings and then remove the casings and send them forth entirely unclad. They have been found to hold their shape well in this condition.

Cellophane, a viscose cellulose product made in a manner identical to that used with viscose rayon up to the very last stages, is also finding widespread applications for wrapping candy boxes, powder puffs, food products, children's toys, and a host of other products sold over the counter. The new cellophane produced by du Pont is water-proof, dust-proof, and fume-proof, and it can be dyed any color and brocaded in any design. It can even be twisted into strands and knitted into ladies' sport hats.

Synthetic Wool

At least two synthetic wool products are on the market. One of these is made from a flax base, the other from waste rayon. Both of these fibers depend for their warmth upon the fact that they have been given a chemical treatment which made them crinkly, and therefore capable of entrapping air. This makes for good insulation but the product is not as good as wool in this respect.

Dyes and Dispositions

The woman of today, be she young or old, can reflect her own individuality in the color of her costume. The man can express himself as colorfully as he chooses in his ties, suspenders, and socks. There are now no restrictions as to the color which one may wear except those of his own disposition.

This was not always true. Although the dyeing industry is one of venerable antiquity, it has been only within the last half or three-quarters

of a century that color in costume was capable of a wide range of choice by everybody in general.

The History of Dyes

The earliest historical records of almost all races of people give fragmentary references to the use of dyes of various sorts. The question as to the nature of the instinct which first prompted members of the human race to desire colored fabrics is one which can be answered only by conjecture. The origin of the word color is of interest in this connection. The Reverend Walter W. Skeat, an eminent authority on the subject of etymology, states that the term color was derived originally from one of two Latin verbs, *celare* or *occulare*, both of which mean to hide, cover, or conceal. Whether this interpretation indicates that the staining of the body as practiced by various primitive races of people may have given rise to the term color or whether the original meaning had reference to the application of coloring matter to a fabric, for the purpose of hiding, covering, or concealing the natural drab appearance of most raw fibers, cannot be answered from the insufficient historical evidence at hand.

Color as a Weapon

An interesting scrap of historical incident showing the practice of staining the body with a dye is given by Julius Caesar in his description of the inhabitants of Britain at the time of his second invasion of the islands, in 54 B.C. In his Commentaries, Caesar describes the inhabitants of Kent, the maritime region in which he first landed, as differing but slightly in dress and customs from their Gallic neighbors across the channel. The inhabitants further inland, however, he describes as possessing a much more primitive type of civilization: "Most of the inhabitants of the interior do not sow corn, but live upon milk and flesh and are clad in skins. All Britains in fact dye themselves with woad, which produces a blue color, and they are therefore more horrible in appearance in battle."

Of course all of us are familiar with the fact that the American Indian made use of color in his military ventures.

Motive for Colored Garments

The reasons why people first began to dye their garments will never be known, for written records were not kept at the time when the practice of dyeing originated. Some philosophers believe that a desire to beautify one's clothing so as to appear well before members of the opposite sex had something to do with the origin of the practice. Others think that human beings were prompted to dye their clothes because of their admiration for the colored ornamentation displayed on all sides by nature.

Color and Rank

Herbert Spencer advanced the so-called Rank Theory, in which he attributed the origin of dyeing and of the use of fancy and distinctive costumes to a desire on the part of the human race to indicate its rank. Thus in the early days when the skins of animals were the chief raw materials for making clothing, the chiefs of the various prehistoric tribes were the ones with the greatest leisure, and consequently killed most game and secured the finest skins. The lowlier members of the tribe had little or no time for hunting and hence they could not compete with their superiors in the matter of dress. In a somewhat similar way, expensive dyes could not be afforded by any but the most wealthy and thus color came to be an indication of rank. At various times, also, certain beautiful colors have been restricted to royalty and the church by law, thus placing restrictions other than expense on their use.

Dyes from Nature

It may be that none of those who have speculated on the reasons why man first began to dye his garments are correct. However he came to do it, it is a fact that he first turned to nature for dyes which were suitable for his purposes.

Mother Nature was very stingy with man in this respect. For, from the beginning of time until about the middle of the nineteenth century, he had found but a bare half dozen dyes of sufficient importance to feature as articles of trade. Berry juices, all sorts of weeds, flowers, onion skins, the barks of trees, the roots of plants, the liquors from fermenting wood, bugs, minerals of various kinds have all been tried with varying degrees of success. Those which have reached a degree of commercial importance are indigo, madder, Tyrian purple, cochineal, logwood, and fustic. A very few others have had their day, but the vast number of the natural dyes have been used only in the home, their use handed down from father to son as great family secrets.

Indigo

Indigo, one of the oldest dyes of which there exists any historical record, is obtained by the fermentative steeping of the stems and foliage of several species of shrubs belonging to the Indigofera family. The juices obtained from these plants are colorless when out of contact with air, but become blue by exposure to air. Fabrics dipped into the colorless juices become dyed with a permanent blue when they are subsequently exposed to air.

Pliny mentions this dye (Indicum) and describes it as being of vegetable origin. As to its exact source and its method of preparation for the market, however, this historian is not absolutely accurate, probably because of the fact that it was of decided advantage for those engaged in the production of the dye to surround its origin with the greatest possible amount of secrecy.

Mummy draperies 4000 years old which are believed to have been dyed with indigo are now in existence. With the introduction of synthetic indigo, the production of the natural product began to decline. In 1897 nearly a million acres of land in India were devoted to the cultivation of the indigo plant; the annual crop from this vast area was valued at something over $20,000,000.

Madder

Madder is a dye consisting of the ground cortex of the root of the madder plant (*Rubia Tinctoria*). When this dye is fermentatively steeped in water it produces a bright red coloring matter. In very ancient times this dye was used by the natives of India, Persia, and Egypt. Herodotus describes the outer garment of the women of Libya, a nomadic African tribe, as being made of hairless tasseled goat-skins, colored with madder. Many ancient Latin writers refer to this dye as *rubia*.

For centuries the production of madder constituted one of the chief industries of Asia Minor and India. As recently as sixty years ago, 50,000 acres in France alone were given over to the cultivation of this plant.

Tyrian Purple

Tyrian purple, the finest and most costly of the dyes of the ancients, was first discovered by the Phoenicians. It was obtained from two species of Mediterranean shell fish, namely the *Murex trunculus*, and the *Murex brandaris*. It is secreted by these animals in a small sac in the throat (if such animals could be said to have a throat), and is used by the animal to color the water and hide its escape when attacked.

The name Tyrian purple was given to this dye because of the fact that in ancient times it was sold by the inhabitants of the rich Phoenician city of Tyre. The wealth of Tyre is said to have been derived quite largely from the sale of this very costly dye.

There is historical evidence to show that Tyrian purple was discovered about 1500 B.C.

The amount of dye secreted by each animal is so small that it required about twelve thousand of the shell fish to produce three grains of the dye. Hence, its high price.

So costly was Tyrian purple, that only kings could afford it. It thus comes to be the badge of royalty, and the Latin term "*purpureo genitus*" was synonymous with the expression "of royal birth."

Dyes and Bugs

Kermes, a crimson dye, was obtained in olden times from the dried insects (*Coccus ilicis*) which frequent the boughs of a species of the oak tree. The insects of this species lay their eggs in groups on the boughs of the

tree. These become covered with a sort of down, so that they appear to be excrescences from the limb itself. The dye is procured from the female of the species, which, when alive, is about the size of a cherry seed. When dead, this creature shrivels up until it is about the size of a grain of wheat.

This dye was known to the Phoenicians before the time of Moses. It was also known to the Greeks and Arabians. The term "crimson" is derived from the Arabian name of the insect, kermes. The crimson frequently spoken of in the Old Testament is supposed to refer to the color derived from this source. This dye was found to be in general use in Europe during the tenth century.

Cochineal, a more recent dye of bug origin, was derived from the dried bodies of the females of *Coccus cacti*, and was found to be in use by the inhabitants of Mexico at the time of the discovery of America. The insects are much smaller than those from which kermes is derived. Cochineal, like kermes, produces brilliant reds. It was introduced into Europe in 1550.

Dyes from Wood

Logwood is the most important of dyes which, at various times, have have been derived from wood. Logwood is a concentrated extract made from chips of the heart wood of a large and rapidly growing tree called by the formidable Latin name—*haematoxylon campechianum*, or campeachy for short.

This dye, if properly applied to fabrics, can be made to give a series of colors, purple, grey, black. With the shortage of German dyes suffered by this country at the opening of the great war, quantities of logwood were rushed into the American market. This dye, in the hands of millmen who were not accustomed to its use, faded and proved generally unsatisfactory. This was the chief reason why the American dye chemist received such a black eye at this time. But little did the public know that it was one of nature's own dye products causing most of the trouble. Without troubling to find out much about the sources of the difficulty, people shouted loudly for "natural dyes," preferably for the "good, old-fashioned vegetable dyes."

Artificial Dyes

It is a matter of history that the natural dyes have always been exceedingly expensive. It was for the purpose of lowering the cost of producing dyes and thus making them cheap enough to be within the reach of all that the chemist conceived the idea of attempting to prepare dye materials by synthetic means. With this end in view, various lines of research were

undertaken for the purpose of determining the chemical composition of the coloring matters of a few of the natural dyes of commercial importance. In order to build up a compound by synthetic means, chemists reasoned that it would first be necessary to know the exact structure of the compound toward which they were working.

The Discovery of Aniline

In 1826, while attempting to analyze the coloring matter present in indigo, the German chemist, Unverdorben, obtained a product which was destined to play an important part in the history of the dye industry. This oily, colorless liquid (turning brown on exposure to air) was later named aniline (so-called from the fact that it was obtained from indigo, *anil* being the Sanskrit for "blue substance" or "indigo"). In 1834 Runge succeeded in isolating from coal tar a substance which was later shown to be identical with the material which Unverdorben had previously prepared during his analysis of indigo. In 1841 Fritzsche prepared aniline by the action of potassium hydroxide on indigo. A. W. Hofmann, professor of chemistry in the Royal College of Chemistry in London, showed that the materials prepared independently by Unverdorben, Runge, and Fritzsche were identical. It was then reasoned that, if aniline could be obtained from indigo, indigo should lend itself to synthesis from aniline. Since no cheap and plentiful source of aniline was known at that time, a new field for investigation was opened up to chemists who were interested in the possibilities of preparing synthetic dyes.

Because of the fact that Runge had prepared from coal tar this substance which seemed to offer some solution to the problem of furnishing a foundation material for synthesizing dye materials, attention was drawn to the possibilities afforded by that very common, and hitherto useless, by-product of the coal-gas industry. Kidd had, in 1821, shown that naphthalene could be prepared from coal tar. The compound which we now call anthracene had likewise been prepared from this source. Hofmann, in 1845, discovered that benzene could be prepared from this source, and that this in turn could be used in the preparation of aniline. After this latter discovery, Hofmann set his student, Mansfield, to the task of working out a method for the separation of coal tar into its various constituents. In the published results of Mansfield's research the first thoroughly organized scheme for separating coal tar into its various constituents by means of the process of fractional distillation was presented. This opened up a veritable storehouse of materials which later proved to be of inestimable value as foundation materials for building up artificial dye compounds.

While Mansfield's work was being done on coal tar, chemists all over the world were trying to analyze the important natural dyes with a view to duplicating them synthetically.

Perkin's Mauve

While the foremost chemists of the day were hunting for means of duplicating natural dyes in the laboratory, William Henry Perkin, an English lad of eighteen years of age, accidentally prepared the first artificial dye. This happened in 1856. Perkin was a student at the Royal College of Chemistry in London, studying under Hofmann. It was his ambition to prepare quinine synthetically. Each time he completed a set of experiments and expected to obtain white crystals of the drug which he wanted to make, only failure greeted him. One day, when pouring a thick, dark-colored, uninteresting looking solution down the sink, he found that when the substance was diluted with water, it had the properties of a dye.

Perkin hastened to take advantage of his find and to investigate the structure of the new material. He found that he could repeat the process as often as he wished, so he placed the substance on the market. He called the new dye, which was a pleasing shade of subdued purple, mauve. He first tried to sell it to the English textile manufacturers, but they were too conservative to buy anything produced in so unusual a manner. He then took the product to France, where the French manufacturers of cloth bought it. Much of the cloth which they dyed with the new product was returned to England where it enjoyed quite a vogue with the English women. So popular did it become, in fact, that *Punch* referred to the situation by saying that the women were suffering from an epidemic of "mauve measles."

The success of Perkin stimulated other chemists to renewed efforts in the matter of analyzing natural dyes and preparing artificial dyes synthetically. The problem of analyzing the commercially important dyes and of finding out how to produce the identical compound in the laboratory proved to be so baffling that some of them required many years to fathom. But every single one of them has been made in purer form than nature can make them. Even the "purple of kings" has been made quite cheaply, but is now used scarcely at all because other synthetic purples have proved to be more beautiful.

Meanwhile, numbers of artificial dyes which have no counterpart in nature at all have been produced. The number has swelled to the hundreds and thousands so that, at the present time, dyes are cheap enough for every one who wants them to afford beautifully colored fabrics. Meanwhile, the commercial production of most of the natural dyes has dwindled to almost nothing at all.

Textiles from Test Tubes

Textiles from test tubes have done more toward creating a world democracy than laws or wars. With rayon and dye plants in all of the countries of the world, what will become of classes and caste systems when we no longer have the aristocracy of dress?

PREPARATION OF BORON FROM BORAX*

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A very interesting and instructive experiment is the preparation of boron from borax. Boron is not one of the elements that are commonly prepared in the laboratory. Its preparation requires very careful technic and manipulation. Boron is not found in the free state, but in combination in boric acid, native borax, boricite, colemanite, and boronatrocalcite. Borax is obtained from minerals, such as colemanite, by treating them with sodium carbonate. Another important compound of boron is boric acid, H_3BO_3; obtained in the United States and South America by treating borax with a mineral acid. In the volcanic regions of Tuscany jets of steam contain nitrogen, ammonia, and boric acid.[1]

The preparation of boron may be divided into six steps: first, treat borax with hydrochloric acid to obtain boric acid, second, dehydrate the acid to form the trioxide, third, fuse the trioxide with magnesium, fourth, dissolve the compounds of magnesium in hydrochloric acid and water, fifth, dissolve boron suboxide in nitric acid, and sixth, dissolve silicon and silica in hydrofluoric acid.

Make a hot saturated solution by dissolving 80 grams of sodium tetraborate in 40 cc. of water. Filter the solution hot, with the aid of a hot water jacket, to remove the insoluble impurities. At relatively low temperatures the solubility of borax and boric acid is low, but at high temperatures these compounds are more soluble. With the aid of a hot water jacket borax and boric acid may be kept in solution. Add concentrated hydrochloric acid until the solution is strongly acid to litmus. On cooling scaly crystals of boric acid separate:

$$Na_2B_4O_7 \cdot 10H_2O + 2HCl \longrightarrow 2NaCl + 4H_3BO_3 + 5H_2O$$

Add water so as to make a volume of about 100 cc. Filter by means of suction and wash the crystals with cold water until they are free of salt. Evaporate filtrate and washings to about 15 cc. and filter with both hot water jacket and suction. Cool the solution and recover the boric acid as before. About 53 grams of the acid should have been obtained.

The second step is to obtain boron trioxide from the boric acid. Place a small amount of the acid in a platinum crucible and heat to redness. If a porcelain or clay crucible is used the oxide will fuse with them. To prevent losses, add small portions of acid as the dehydration proceeds:

$$2H_3BO_3 + \text{heat} \longrightarrow B_2O_3 + 3H_2O$$

About 30 grams of the trioxide should be obtained from the 53 grams of acid. The oxide is very brittle. Like the oxide of aluminum it is some-

* Winner of ten-dollar award in the student contest closing February 15, 1929.

[1] J. R. Partington, "Textbook of Inorganic Chemistry," Macmillan, p. 733, 1925.

what amphoteric; it is weakly acidic and yet it shows feebly basic properties toward very strong acids.[2]

The next part of the preparation is the most important and also the most difficult to accomplish. Different proportions of boron trioxide and magnesium powder give different results. If boron trioxide is heated with the theoretical quantity or an excess of magnesium, magnesium boride is formed almost quantitatively. For the highest yield of boron one should fuse three parts by weight of boron trioxide with one part of magnesium powder.[3] This ratio is necessary because several possible reactions may take place:

$$B_2O_3 + 3Mg \longrightarrow 2B + 3MgO$$
$$3B_2O_3 + 3Mg \longrightarrow Mg(BO_2)_2 + B_4O_3 + 2MgO$$
$$B_2O_3 + 6Mg \longrightarrow Mg_3B_2 + 3MgO$$
$$5B_2O_3 + 12Mg \longrightarrow 8MgO + Mg(BO_2)_2 + Mg_3B_2 + B_4O_3 + 2B$$
$$3SiO_2 + 4B \longrightarrow 2B_2O_3 + 3Si$$

The silica comes from the clay crucible, in which the fusion takes place at a red heat.

When the vigorous reaction ceases, cool and place the crucible in dilute hydrochloric acid (1:2) and boil gently for about one hour. This treatment will loosen the mass so that it can be removed from the crucible.

Grind up the fused mass to a fine powder, add about 75 cc. of concentrated hydrochloric acid and heat almost to boiling for one hour. Dilute with 100 cc. of hot water and filter with suction and hot water jacket. The filtrate will contain the soluble magnesium compounds:

$$MgO + 2HCl \longrightarrow MgCl_2 + H_2O$$
$$Mg(BO_2)_2 + 2HCl + 2H_2O \longrightarrow MgCl_2 + 2H_3BO_3$$
$$Mg_3B_2 + 6HCl + 6H_2O \longrightarrow 2H_3BO_3 + 3MgCl_2 + 6H_2$$
$$MgO + Mg(BO_2)_2 + Mg_3B_2 + 10HCl + 8H_2O \longrightarrow 5MgCl_2 + 4H_3BO_3 + 6H_2$$

The mixture on the paper will contain boron, boron suboxide, silicon, and silica; about 7 grams should be obtained. The low yield shows that a large portion of the boron is lost, because after being reduced by the magnesium it reacts with more magnesium to form magnesium boride and magnesium borate. These two salts react with hydrochloric acid and form boric acid, which may be recovered.

Before 1909 it was thought that boron at this stage contained only silicon and silica as impurities, but in that year Weintraub stated that

[2] J. R. Partington, "Textbook of Inorganic Chemistry," Macmillan, p. 735, **1925.**

[3] J. W. Mellor, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," Longmans, Green and Co., Volume V, p. 8, **1922–27.**

boron suboxide is present also. He also stated that pure boron is insoluble in 40% nitric acid:[4]

$$B_4O_3 + 2HNO_3 + 5H_2O \longrightarrow 4H_3BO_3 + 2NO$$

In order to separate these add $6N$ nitric acid drop by drop. If the acid is added in large volumes the reaction is more violent and may cause a loss of some of the boron. When no further action occurs add about 25 cc. of water and heat to boiling. The remainder of the boron suboxide will be dissolved by the acid and leave the silicon, silica, and boron, which are insoluble in nitric acid. Filter with both suction and hot water jacket. The greater portion of the boron mixture is dissolved by the above treatment, showing that boron suboxide constitutes the greater part of the seven grams treated. Only 1.5 grams of boron containing silicon and silica are obtained.

The chestnut brown powder, left on treating the mass with nitric acid, may be purified by treatment with hydrofluoric acid. Add about 10 cc. of hydrofluoric acid to the powder in a platinum dish and allow this to digest on a steam-bath for fifteen minutes:

$$SiO_2 + 6HF \longrightarrow H_2SiF_6 + 2H_2O$$
$$Si + 6HF \longrightarrow H_2SiF_6 + 2H_2$$

Filter the hot solution through a hard rubber funnel and take care to have sufficient water in the beaker receiving the filtrate, so that the acid will not attack the glass too readily. Wash the boron with hot water and finally dry in an oven. For the theoretical yield 9 grams of boron should have been obtained, but due to the formation of magnesium boride and magnesium borate only 1.2 grams are obtained.

Boron so prepared is in the amorphous form and is a chestnut brown powder which is unaltered in air at ordinary temperatures, but it smoulders when heated to a dull redness. Boron burns slightly when heated to redness with the formation of boron trioxide and boron nitride, which produce a superficial coating that prevents complete oxidation. Boron is one of the few elements that combines directly with nitrogen.[5] A crystalline form is said to have been prepared; this form is not really crystalline boron, but an aluminum, carbon, and boron compound, probably $B_{48}C_2Al_3$.[6]

Boron has practically no industrial uses, but its compounds are used for a number of commercial purposes. This method of production is too costly, and if boron finds a place in industrial chemistry, some other less expensive method of extraction will have to be devised.

[4] J. R. Partington, "Textbook of Inorganic Chemistry," Macmillan, p. 736, **1925.**

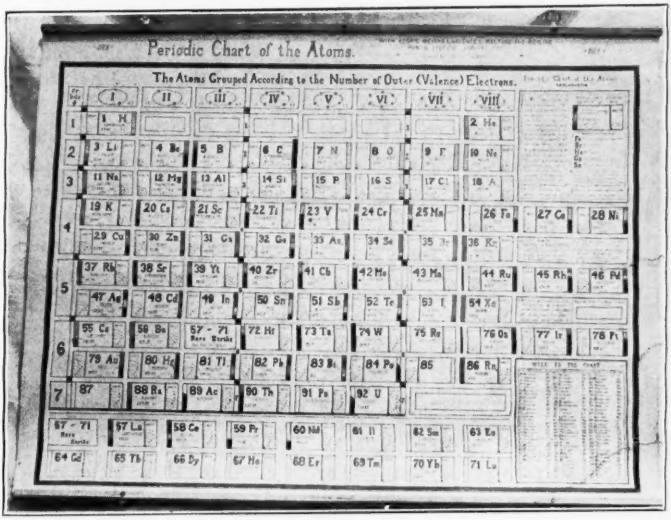
[5] J. R. Partington, "Textbook of Inorganic Chemistry," Macmillan, pp. 735–6, **1925.**

[6] J. W. Mellor, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry," Longmans, Green and Co., Volume V, p. 10, **1922–27.**

A PERIODIC CHART OF THE ATOMS*

STUART GRAVES, WILLIAM NOTTINGHAM HIGH SCHOOL, SYRACUSE, NEW YORK

The chart shown in the accompanying illustration was drawn because of a desire on the part of the writer for a quick source of reliable information concerning the various chemical elements. In general design it is very similar to that of a chart compiled by Henry D. Hubbard of the U. S. Bureau of Standards. It does not, however, contain any information on subjects which cannot be readily understood by the student in high-



A PERIODIC CHART OF THE ATOMS

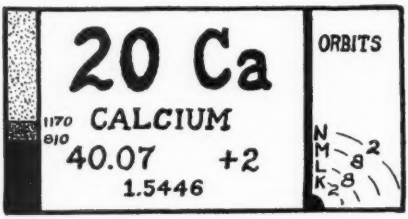
school chemistry. Placed on the wall of the home laboratory or study room, it has proved to be of great value in studying or in experimental work, as its use eliminates all loss of time in turning the pages of a book, in search for a table of atomic weights, valences, specific gravities, or other information.

It is drawn in colored inks on a 32- by 24-inch sheet of mounted paper. Each of the ninety-two units contains the atomic weight, valence, etc., of one separate element. These units are arranged horizontally according to the number of orbits of electrons outside of the nuclei of the atomic systems, and vertically according to the number of electrons in the outside orbits of these atomic systems. The Arabic row numbers on the left-hand

* Winner of five-dollar award in the student contest closing February 15, 1929.

side designate the number of orbits in the atoms of that row, and the Roman column-head figures show the number of outer or valence electrons in the atoms of that column. In the lower right- and left-hand corners of the column-head sections are figures denoting the positive and negative valences of the elements below. Over elements 21 to 28, 39 to 46, and 57 to 78 a dotted line has been drawn, showing that these elements depart from the general rule and do not have the number of electrons in their outer orbit which the column head designates. The rare earths (atomic numbers 57 to 71), being of less importance, have been placed at the foot of the chart.

The second cut shown is a duplicate of the unit on the chart which contains the properties of the calcium (Ca) atom. The figure 20 in the upper left-hand corner is the atomic number of the element calcium and the upper right-hand corner contains the symbol. If this symbol is in black, the element is a solid at ordinary temperatures; if in blue, it is a liquid; if in red, it is a gas; and if in brown, it is a so-called "rare earth."



EXACT-SIZE DUPLICATE OF THE CALCIUM UNIT

The small figure at the lower right-hand corner of the symbol shows the number of atoms in one molecule of the element, if this is known. Thus, by multiplying the atomic weight of the element by this small figure, the molecular weight of the element is obtained. In the center of the unit is the name. If this is in green, the element is a metal; if in brown, it is a non-metal. A green asterisk before the name of a non-metal shows that the element has metallic properties, and therefore we find this green mark before the name "hydrogen." A brown asterisk denotes a metal with non-metallic properties. We find such a mark before the name "chromium." Below the name of the element, at the left, is the atomic weight, and at the right of this is the valence. At the bottom we find the specific gravity. If this is printed in blue, the specific gravity is based upon the assumption that water = 1, and if it is red, air = 1. At one side of the unit is a diagram that shows the number of electrons in each orbit of that atomic system. At the opposite side there is a melting- and boiling-point graph. On this graph one-sixteenth of an inch equals 163 degrees, absolute temperature. The space on the graph through which the element remains a solid is colored in black; where it is a liquid the graph is blue; and where it is a gas it is red. The melting point in degrees Centigrade is printed in blue at that point on the graph where the element melts, and the boiling point is printed in red at its point on the graph.

By the arrangement of the units on this chart, elements of one family are seen to be in the same vertical column. Thus we find fluorine, chlorine, bromine, and iodine in the number VII column. The elements in one column which have their melting- and boiling-point graph on the same side of their unit more nearly resemble each other than those which do not.

The chart is completed with a legend in the upper right-hand corner and an index to the elements in the lower right-hand corner.

TINNING AND ZINCING

C. P. STEVENS, ALHAMBRA UNION HIGH SCHOOL, MARTINEZ, CALIFORNIA

The following experiment may be used to demonstrate a method for plating protective coatings of tin, zinc, and other metals on iron.

The article to be plated should first be well cleaned and then pickled in sulfuric acid sp. gr. about 1.66. It may then be placed, after washing, in an ordinary Pyrex test tube with the right amount of tin or zinc. On top of the tin or zinc should be placed the flux to prevent oxidation. After the metal has been melted, a very satisfactory coating of tin or zinc should be found adhering to the iron.

For a flux, ammonium chloride serves very well although tallow, zinc chloride, and palm oil may also be used.

STUDENT CONTRIBUTIONS

Is your chemistry club carrying on some worthwhile project? Have you, yourself, an interesting chemical hobby? Have you devised an original chemical experiment or piece of apparatus? Have you built a working model of a chemical plant or a piece of chemical machinery? Have you a chemical collection of any kind?

Tell us and other students about it in an article of not more than one thousand words. If possible, illustrate your article with drawings or photographs, or both. In preparing your manuscript, observe the directions to authors set forth on page 408.

Ten dollars will be awarded the high-school or undergraduate college student contributing the best item received on or before April 15, 1929. Five dollars will be paid for any other articles accepted for publication. Address your contribution to the Associate Editor, JOURNAL OF CHEMICAL EDUCATION, The Johns Hopkins University, Baltimore, Md.

THE NUMBER OF ATOMS IN THE SULFUR MOLECULE*

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The molecular weight of sulfur is to a greater degree than that of any other element dependent upon the temperature. Below the boiling point there are eight atoms in the sulfur molecule. Somewhat above the boiling point the molecule becomes smaller. At a temperature of 467.9°C. the vapor density of sulfur is 114.89 and at 860° it is only 32.3. At 860°, therefore, the molecule contains 2 atoms, as the molecular weight is double the vapor density. Above this temperature, the vapor density remains constant until about 1800° when the molecule begins to dissociate. At 2000° and 380 mm. pressure the dissociation reaches about 45%.

The determination of the density of sulfur vapor is too difficult for the average experimenter, but another method, applied to solid sulfur, can be carried out with little difficulty and fair accuracy. This method is based on the fact that one gram molecule (the molecular weight in terms of grams) of any substance dissolved in an equal amount of the same solvent lowers the freezing point of that solvent an equal number of degrees. It is evident, then, that by measuring the depression of the freezing point of a solution of known concentration the molecular weight of the solute can be calculated if the molecular lowering of the solvent is known. The molecular lowering is the number of degrees that one gram molecule of any substance dissolved in 1000 g. of solvent lowers its freezing point.

The apparatus used for the determination is set up as follows. Select two test tubes of such size that one will fit within the other and hang suspended by its rim. The purpose of the outside tube is to produce a dead air space around the inside one and thus prevent sudden changes of temperature. Fit a two-hole stopper to the inside tube. Place an accurate thermometer through one hole and a small stirring rod through the other. The stirring rod should fit loosely enough that it can easily be worked up or down, and its end should be bent to form a semicircle around the thermometer.

To carry out the experiment, place 5 g. of pure naphthalene in the inner tube and suspend the whole apparatus in a beaker of water. The water level should be slightly higher than the level of the naphthalene when melted. Heat the beaker until the naphthalene melts, then remove the source of heat. Be sure that the whole bulb of the thermometer is immersed in the naphthalene and that it does not touch the sides of the test tube in any place. Stir the molten chemical continually as it cools. At a temperature of around 80° flakes of solid naphthalene will begin to form and the temperature will remain constant until the chemical has solidified. Determine this temperature to a tenth of a degree by means of

* Winner of five-dollar award in the student contest closing February 15, 1929.

a good reading glass or other appliance. Remelt the naphthalene as above and dissolve in it exactly 0.5 g. of flowers of sulfur. Determine the point of solidification of this solution as above.

To determine the molecular weight of sulfur from the data obtained, divide the number of degrees the freezing point was lowered by 100 (to find the number of degrees 1 g. sulfur in 1000 g. solvent would lower the freezing point) and divide the figure thus obtained into 7.1 (the molecular freezing point lowering for naphthalene). The results will only be approximate with the crude apparatus used, but if the experiment was carried out as accurately as possible, the figure obtained should fall between 254 and 263. These figures are approximately 8 times the atomic weight of sulfur, 32.064, thus showing that the molecule contains 8 atoms at the temperature at which naphthalene melts.

The above method can be used for determining the molecular weight of any substance for which a suitable solvent can be found. The molecular lowering is, however, different for each solvent.

Drug, Peyote, Haled into French Court. The Tribunal of the Seine has been requested to place a ban on the sale of peyote, a drug obtained from the Mexican cactus, known by the same name to the Indians, but labelled *Echinocatus willamsii* by botanists.

This species of cactus, scarcely larger than a man's hand, is cultivated in the mountains inhabited by the Huichoiz Indians and until recently was scarcely known to drug peddlers. Recently, two Bordeaux merchants began the exploitation of peyote in Paris.

The novelty of it, its sacred character to the Indians, the apparent lack of after-effects and the fact that doctors consider it as non-habit forming, created a brisk trade. It produces a state of ecstasy unequaled by any other known drug in intensity and differs from them in that it creates a kind of visual intoxication which the Indians call miraculous. In his delirium the subject "sees visions." The Tribunal of the Seine has been petitioned by Doctors Rouhier and Perrot to have the public sale of peyote outlawed.

The sale of the drug has already been forbidden in the United States and Germany. —*Science Service*

Magnetism Tests Metals without Harming Them. Magnetism, working silently without injuring metal, is a testing tool coming more and more into industrial and research use, Raymond L. Sanford, chief of the magnetic section of the U. S. Bureau of Standards, recently told the American Institute of Electrical Engineers.

Case-hardened chain, heat-treated forgings, and steam turbine bucket wheels are among the products now given a routine magnetic analysis to detect flaws and insure quality.

In exploring the qualities produced by new steel treatments, in determining the changes that take place during the cooling or heating of a ferrous alloy, magnetic analysis is used by scientists investigating the properties of materials.

Inspection of welds is facilitated by magnetic methods. Since welding is coming into larger industrial use, the magnetic test will facilitate the control of this modern method of joining metals together.—*Science Service*

Correspondence

"INTRODUCTORY QUALITATIVE ANALYSIS," BY CORNOG AND VOSBURGH

I have just read a book review published in the January, 1929, JOURNAL OF CHEMICAL EDUCATION. The review is by J. E. Zanetti, of Columbia University, on the "Introductory Qualitative Analysis," written by Jacob Cornog and Warren C. Vosburgh. This book is published by the Macmillan Company, New York.

The review is distinctly unfair for the reviewer leads one to believe that the course would require only thirty clock hours. The words "thirty clock hours," the reviewer has placed in quotation marks. The sentence from which he quotes reads as follows, "Students of fair ability will require about thirty clock hours for the execution of the laboratory work thus far described"—while on page five, preface, the authors make the following statement, "The authors have as their purpose in this book the organization and presentation of a quantity of subject matter, fairly proportioned between experiment and theory, comprehensible to most second semester freshmen, and capable of being presented in approximately one hundred clock hours or less of laboratory time."

The reviewer also comments on the serious error on page 62. He criticizes the formula for nickel dimethyl glyoxime and worries about the future analytical chemist who has such "an unfortunate" idea instilled into his mind. Baskerville and Curtman in their "Qualitative Analysis," also published by Macmillan, draw the structural formula for this compound and show the nickel replacing two hydrogen atoms from the molecule of dimethyl glyoxime but also show one molecule of dimethyl glyoxime somehow associated with the nickel dimethyl glyoxime. Further, in the rather excellent Treadwell-Hall "Analytical Chemistry," Volume I, Page 186 (1921 edition), an error in the writing of the equation showing the formation of nickel dimethyl glyoxime has occurred. The authors here write $Ni(C_8H_{14}N_4O_4)_2$. The error is of course quite obvious, but still it is an error. I wonder if the reviewer would have been so caustic with this volume.

Some of the other criticisms of the reviewer also seem to be mere quibbling.

Now, to come to my point. If I were looking about for a book to use in qualitative analysis and had taken the aforementioned review at face value, I would never have even glanced at Cornog and Vosburgh's book.

This would have been decidedly unfair to the authors for the reviewer has misrepresented their book. It seems to me that it would be better to leave a book review unwritten until a really careful and scientific examination of the book is made. It is particularly unfair when "the book cannot be recommended as a whole for a serious course." I have no personal interest in the book, the authors, or the reviewer, but would like to put in my plea for book reviews which are fair and just.

Z. T. WALTER

BRAWLEY UNION HIGH SCHOOL
AND JUNIOR COLLEGE,
BRAWLEY, CALIFORNIA

THE WÖHLER PLAQUE[1,2]

I am writing to inform you of an interesting bit of information that has come to me as a result of sending a copy of my Wöhler paper to Dr. F. W. Frerichs, 4557 W. Pine Blvd., St. Louis, Missouri. As you may know, he was at one time connected with the Mallinckrodt Chemical Co., and then became a member of the firm of Herf and Frerichs, Manufacturing Chemists. Concerning Wöhler he writes: "I had the great privilege to work under Wöhler's direction for 9 years and owe to him whatever success I made in my profession." But what is even of more interest is the following:

"I notice that on page 1550 of your paper you refer to a plaque of Wöhler, the origin of which is unknown to you. The plaque resembles very much a plaque which I saw on the occasion of the annual meeting of the American Chemical Society in Pittsburgh, Pa., in 1892, when we inspected the plant of the Aluminum Co. of America in New Kensington, Pa., where the first two furnaces making less than 100 pounds of aluminum per day by the Hall process were operated for our benefit. The Company had cast in aluminum a plaque similar to the one you describe, about 8 in. in diameter, and sold it to the visitors at one dollar apiece. I bought one but lost it in a fire which destroyed my office about 12 years ago, and for this reason I cannot give the exact dimensions. Possibly the specimen you hold is of the same origin."

I thought you might be interested in getting a possible explanation of the plaque of unknown origin, especially as it seems to have been connected with an early meeting of the American Chemical Society.

WILLIAM H. WARREN

CLARK UNIVERSITY
WORCESTER, MASS.

[1] See THIS JOURNAL, **5**, 1550 (Dec., 1928).

[2] Any further information concerning this plaque will be appreciated.

In response to our inquiry addressed to the Aluminum Co., the following information was received:

We have in our possession a pattern, from which at various times, castings similar to the one you mentioned, have been made. We also know that a number of these castings were presented to members of the American Chemical Society who visited our plant at New Kensington in 1892. It stands to reason, then, that if Dr. Remsen was among the party which visited the plant, in that year, he was probably given one at that time. We have no record of the names of the men who made that visit, and we also know that similar castings have been made abroad.

It is therefore impossible to positively identify this plaque as one that was cast here, although circumstantial evidence makes me believe that it was.

ALUMINUM COMPANY OF AMERICA
W. C. WHITE

PITTSBURGH, PA.

COMMERCIAL MATERIAL FOR SCIENCE CLASSES*

It would seem from an occasional letter which we receive that our name appears in your JOURNAL among a list of firms who are willing to send material of interest and value to instructors of chemistry in the various schools throughout the country. This has been interpreted in many cases to mean that we have samples of materials showing steps in manufacture, etc. As a matter of fact, the only material which we have is printed matter such as our catalog on Reagents and "C. P.'s," which we publish from time to time.

Will you therefore kindly edit the note in your esteemed JOURNAL in accordance with this information.

MERCK & CO., INC.
C. S. ROBERTSON

RAHWAY, N. J.

*See abstracts from *Science Classroom* (Sept., 1928), THIS JOURNAL, **5**, 1350 (Oct. 1928); **6**, 158 (Jan., 1929).

Mixed Fertilizers in Germany. It is expected that the production of mixed fertilizers in the new factory of the Kali-Industrie A. G., of Kassel, and the Klocknerwerke, of Rauxel, will soon start production. It is planned to produce a high percentage of nitrogen and potash fertilizers from ammonia and crude potash, to replace to a considerable extent the sales of simple potash products and obviously to compete with the Nitrophoska of the I. G. Farbenindustrie. The Kali Industrie's second new factory in Sondershausen, for the same kind of fertilizer, the construction of which was started about nine months ago, is also nearing completion.—*Chem. Age*, **20**, 19 (Jan. 5, 1929).

Chemical Digest

TEACHING STUDENTS HOW TO STUDY

That failures in college are generally not due to lack of intelligence but rather to neglect on the part of teachers to give adequate instruction in the art of study is the belief of Prof. Guy M. Whipple,[1] of Minnesota. This conclusion was reached through information gained from failing students in one of the larger universities. Among 324 students on probation one in six declared their failures to have resulted in part, at least, from the absence of such instruction in their high-school careers, while approximately one in three stated that the cause of their failures lay in the difficulty found in adjustment to conditions prevailing at college. The latter factor is shown by the author to be closely related to the first since the change to the college environment is largely found in methods of classroom instruction and in the conditions under which the preparation for classes is done.

That the art of study ought to be learned in the preparatory schools is not questioned. High-school students are well able to grasp and to practice the fundamental principles of study and yet we are confronted with the fact that, save in exceptional cases, the high schools fail to give their charges the needed practice in the art. "Consequently, the college must undertake it or pay the penalty of a lower-than-need-be level of student efficiency."

The question whether the students desire this training was answered for the author by an illuminating experience. He says:

> I was asked to talk to a group of a dozen high-school students on how to study. When I was finally convinced that they really wanted this talk, I consented to undertake it. I was surprised and delighted at their reception of my efforts; they listened attentively, discussed the matter intelligently, asked a number of salient and even difficult questions, and furthermore took the trouble several months later to visit me, in order to report how much their school marks had improved as a result of putting into practice some of the suggestions we developed. That was my first experiment in training pupils how to study. It cured me of my notion that students were indifferent to the problem, that they would adopt a more or less bored and cynical attitude toward what I feared sounded like preaching.

Sometime later after the material of this talk had been expanded into book form the principal of a high school conducted an experiment to measure the effect of the instruction given in this book upon a freshman class. The class was divided into a training and a control section and the

[1] *J. Educ. Res.*, **19**, 1–12 (Jan., 1929).

school records of these groups were compared at the completion of the semester. An episode of scientific value is described which, as the author states, "nearly wrecked the whole undertaking:"

> Several students in the control section had become indignant because they were getting none of the special instruction that was being given to the training group; a number of them got their heads together, discovered from one of their mates what book was being used in the training group, sent off an order for it to the publishers and were reading it on the sly!.....Answer enough, I think you will agree, to the question: Do students really desire training in how to study?

A second question raised is whether the better endowed students can profit from this training. Special training, thus far, has generally been directed toward the incompetent student. Many prominent educators believe that instruction in studying ought to be given to all students who really want to improve their methods of work. Practice experiments in psychology have shown that subjects who are competent at the beginning usually gain more from the practice than those who are less competent at the start. The objection that no suggestions for effective studying may be made that are not known to bright students is met by the reminder that better ways of doing something that one has already been doing reasonably well are likely to occur even to a college professor. The author believes that an intelligent student may gain much to his advantage through this training and he recommends that courses in the art of study be given to all students.

A third phase of this experimental work grew out of the observation that although the majority of high-school pupils can understand every important rule for effective studying, the application of these rules to the actual processes of studying is quite a different thing. Accordingly, a series of successful study exercises were devised to train in following the rules which are used. These exercises served to make the rules more real, enabled the students to practice them and started them on the road to correct habits of mental work.

> There was no doubt that these exercises increased the interest of the students in the work and assisted the teachers in keeping concrete illustrations of the technic of study before the students.....The instruction of students in the rules for effective studying must be supplemented by some device for guaranteeing the practice.

Attention is called to the work reported by Prof. Jones[2] of Buffalo in which special pre-collegiate classes consisting of the prospectively poorer freshmen, were instituted three weeks before the university opened in the fall, in which classes there was given an intensive preliminary training in study. The training comprised mainly these six things:

[2] *Personnel J.*, **6**, 182–91 (1927).

1. A stiff regimen of composition writing,
2. Drill in rapid reading, with tests of comprehension,
3. Drill in mathematical problems,
4. Lectures on note-taking, mental hygiene, attentiveness, memorizing, etc.,
5. Drill in note-taking, and
6. Assigned readings.

The outcome was shown to be especially favorable in raising the college performance of the lowest fifth of the high-school seniors.

The author points to the report of Book[3] in which it was estimated that:

> . . . ninety per cent of the information acquired by students is obtained by reading, and that the majority of freshmen known to be doing poorly in college are also defective in reading ability. . . . . The effect of eight weeks special instruction in rapid reading is estimated to have been an improvement of 102 per cent in ability to read and 60 to 97 per cent in ability to prepare a standardized assignment.

Book shows further that the net outcome of how-to-study instruction, given a class of university freshmen as measured in terms of credit points earned per semester, to be an increase of approximately 50 per cent in academic credits.

The experiments described are sufficient proof that "college freshmen need training in reading, in conserving their time, and in planning their college work." The author goes further in considering what may widely be included in the training for effective study. Certain desirable features in a campaign for better studying may be grouped around eight main rubrics that students need to know as follows:

A. Knowing what physical and mechanical conditions are favorable to studying. Under this heading is stressed the need of keeping in good physical condition, of paying attention to ventilation and light, of providing tools of study as pencils, drawing-sets, dictionaries, etc.

B. Knowing where, when, and how long to study. This would include the budgeting of time.

C. Knowing how to concentrate attention. Stress should be laid on getting started promptly, on development of attitudes of persistence, of intent to learn, of avoidance of worry, excitement, and distractions.

D. Knowing the general rules of procedure in studying. These should include understanding the aim; quick reviews; learning rules and definitions before trying to use them; suiting pace and style of reading to material in hand; enlarging vocabulary daily; making use of aids to study in library (card catalogs, encyclopedias, etc.); locating one's own weak points and giving special attention to them.

E. Knowing how to think over and apply what has been learned. The students should get away from sheer memory and convert information into material to be put into personal use. He should work out his own illustrations of principles; maintain a questioning attitude; try to anticipate conclusions presented by lecturer or author; make outlines of reading; consider both sides of all controversial questions.

F. Knowing how to learn in the classroom. This includes taking notes, and following the contributions of fellow students persistently and critically,

[3] *Sch. & Soc.*, **26**, 242–8, 529–34 (1927).

G. Knowing what to commit to memory and how to do it economically. This will aim to show what sort of material should be memorized and what should not, and will include the most common rules for committing to memory economically.

H. Knowing how to prepare for, and how to take, examinations. This instruction should include the time to begin reviewing, the attitude to be assumed when confronted by the examination, the way to organize replies to questions, re-reading papers before submitting them.

The author concludes by saying that "Such instruction in methods of study is needed; it is welcomed by the students; it ought to be done in the secondary schools but is not and, consequently, the college must assume the responsibility." R. M. P.

THE HIGH-SCHOOL TEACHER AND RESEARCH[1,2]

On what fields of research can a high-school teacher of chemistry work? Some possible fields are: (*a*) unapplied chemical research as carried on by science departments in various colleges; (*b*) applied research in coöperation with some industry; (*c*) research in purely educational fields; (*d*) research in education applied to teaching of chemistry.

A high-school teacher working in unapplied chemical research is competing at a disadvantage in a field already crowded with college professors and graduate students. Colleges have the needed frequently costly equipment for this work, while the high-school man has meager equipment and hardly dares ask the school to furnish any special apparatus. Too, his papers would probably receive scant attention from the editors of scientific publications. Any such work should best be done in coöperation with a college professor whose prestige would insure careful consideration of any papers submitted for publication.

In applied chemistry the high-school chemistry teacher would have to work in connection with some industrial plant which would demand the non-publication of results. Too, he has little time to work in a factory laboratory. Outside activities of the school, such as science clubs, helping with athletic events, football coaching, etc., would prevent his regularly working in any factory. Such work would have little in common with his teaching load. But this work would broaden him by exposing him to the industrial viewpoint.

Research in purely educational fields, such as testing, leads the teacher from the chemistry fields into administrative work. His scientific viewpoint, however, would make him stand out in contrast to the "usual run"

[1] Rufus D. Reed, *Neo-Chemto-Ion*, **3**, 18, 20 (Nov., 1928).

[2] This is the second of a series of articles on Research by Dr. Reed. See THIS JOURNAL, **5**, 1694 (Dec., 1928) for abstract of first article.

of English and history teachers who have entered the administrative and testing fields. One prominent university had five deans who had been trained in their chemistry department. This shows the worth of scientific training. But just now competition is very keen in the fields of purely educational research.

The field of research in chemical education is new. The number of college professors who are working in the field are few. In fact few college professors are competent to work in this field. Many college teachers know chemistry and despise pedagogical training or know educational principles and despise a thorough knowledge of chemistry. Research in teaching of chemistry by college chemistry professors is bound to be unpopular so long as college deans say "we keep him (professor) as far as possible from all 'schools of education.' "

The high-school chemistry teacher has in many cases as adequate a subject-matter training in his particular work as the college man has for his work. In addition he has from one-half to one year's training in pedagogy which the college teacher is taught to despise. The high-school teacher needs to do more teaching research than the college teacher because he must meet two requirements: keep his failures down to a minimum to escape criticism by parents, superiors, and the board of education of being too hard and wasting the public's money; and give his pupils an adequate knowledge of subject matter so that they can use it either in routine industrial work or pursue advanced college work with credit to the school. Such research is connected with his subject and therefore does not scatter his efforts to the detriment of his work.

THE FORMATION OF THE ÉLITE

Every school gains renown not only through the scientific achievements of its professors, but also because of the industrial successes of its former students. Schools have been a potent factor in the development of an intellectual élite, the class responsible for the progress of civilization in any country. . . . . The formation of an intellectually superior class should be the dominant preoccupation of any country that expects to cut a figure in world affairs.

With these remarks, Professor Henry M. Le Chatelier[1] prefaces an interesting and rational discussion of the "conditions attendant upon the recruitment of the intellectual élite." The intellectuals are placed on three levels:

1. The men of genius, whose fame and influence extend throughout the world for many centuries.

[1] "The Formation of the Élite" (trans. by R. E. Oesper), *Sci. Mo.*, 212–24, Sept., 1928.

2. The great men, whose renown, however great at a given time, is finally eclipsed by that of their successors.

3. The lower élite who temporarily exert a useful influence within rather narrow boundaries, but never attain far-reaching notability.

The author estimates that approximately the same volume of service to humanity is rendered by each of these three categories; the greatest benefactors undoubtedly being the men of genius, who, however, occur most seldom. But, then:

> It would surely be folly for any one to deliberately set out to become a genius, because this goal can only be reached through certain exceptional qualities, but we all can and should strive to be numbered among the élite, to use this term in its proper sense. With the exception of certain afflicted individuals, fortunately not numerous, all of us from birth have the requisite qualities. The rest is dependent on will power and on the method of developing and applying our natural endowments.

With these facts in mind, Professor Le Chatelier presents to us, without distinguishing between the suggested levels of attainment, the four qualities he considers essential for the formation of an intellectual élite.

1. Activity

> The most striking characteristic of great men is their zeal for work. None of them observed the eight-hour day, no matter what the field of their activities. . . . . Great men have labored much, but their efforts have been confined to a few specialties, thus increasing the intensity of their work. . . . .
>
> This concentration of effort cannot be recommended too highly to young investigators, for they frequently exhibit an opposite tendency and allow themselves to be enticed from one thing to another by topics which appeal to them. . . . .
>
> It is not sufficient to work hard, but it is also essential to work efficiently, *i. e.*, time must not be wasted on useless projects. A plan of attack should be formulated in advance of starting the actual work or writing, so that there need be no hesitation. Attempts to do two things at the same time are usually fruitless, and it should be a matter of principle not to stop working until something definite has been achieved. Learn to persevere and do not hesitate to adhere to a decision made after proper reflection. . . . .
>
> Much gain may accrue by organizing the vague, spontaneous thoughts which the mind cannot supress, even though they appear to have little value. We are always thinking about something, and this involuntary thought is much less fatiguing than mental effort consciously directed toward definite production. This preparatory reflection is sometimes erroneously regarded as being quite distinct from the real work, but this opinion is quite wrong, for preliminary thought is an essential forerunner of all creative achievement. In fact, it is just as indispensable as the final effort and the latter will certainly be of little avail if the way has not been properly prepared. If the mind could be trained not to think useless thoughts, the productive capacity would be enormously enhanced.

But can this zeal for work be developed? Is it a natural gift or the result of education?

1. The greatest stimulant of activity is habit, which proverbially becomes second nature. . . . . After the habit of working is once formed, a man will work for the mere joy of working just as we walk for the pleasure of the exercise. It has become a necessity.

However, this habit is not easily acquired. Temperament plays some part. Certain children, from birth on, exhibit more will power, have more acute faculties of attention, are more persevering, all of which are essential to the accomplishment of a protracted task. Yet these predispositions are, in general, developed only to a slight degree and play only a minor part in the differentiation of individuals. Other factors seem to be of greater importance. . . . .

2. A second very potent factor is ambition; that is, the desire to acquire riches or honors. Men not favored by the fortunes of birth sometimes struggle with extreme energy to make a place for themselves. . . . .

3. A third stimulus, more noble than those already discussed, is the attraction inherent in the fruits of labor; *i. e.*, the joy of knowledge and the pleasure of performance. The passion for knowledge or for success in a chosen field often arouses men who by temperament or habit might have been inclined to loaf. . . . .

4. This joy in work may be developed by education and without difficulty. Success is assured if less attention is given to preparing for examinations and more stress laid on the intellectual molding of the children. From their earliest years they have a wide-awake curiosity, they continually ask why and how. Instead of eradicating this disposition, it should be cultivated. Science courses lend themselves wonderfully to this end. Emphasis should be placed on the linking together of facts, which is the essence of the scientific method, discarding the fastidious enumeration of isolated facts which so overburden the memories of pupils to-day. . . . . Much less intellectual effort is required to comprehend the demonstration of a truth if actual experimentation has previously made the reality familiar.

5. A final incentive to the ardor for work is good health. The thought of working or still more of getting to work; *i. e.*, the wish to do something, involves, if not a true fatigue, at least a feeling of fatigue which leads many to shrink back. A good digestion and restful sleep make the thought of work much more agreeable. This does not imply that a strong will cannot overcome the weakness arising from poor health, for there are remarkable instances of such victories, but they are rather exceptional. . . . . Physical culture should occupy an important place in the education of the young; it is indispensable in the formation of the intellectual élite of a nation. . . . .

2. Imagination

It is not sufficient for a useful member of society merely to work hard and produce much for his own benefit; he should contribute to the common fund of knowledge by producing new ideas, discovering scientific laws, devising new literary or artistic presentations, perfecting methods of government. Thus, he must play a creative rôle. But by what mechanism is this progress realized? We quote further:

Contrary to popular belief, our knowledge does not increase by leaps and bounds, but the development is regular and very slow. Each step forward, in the majority of cases, comes from the simple combination of facts previously known. It is only necessary to delve in the storehouse of knowledge and to bring new relations to light. This correlation is a fruit of the mental faculty, imagination, whose functioning is rather capricious. The solution of a problem may be sought unsuccessfully for a long time,

and then suddenly it may flash into the mind at a time when the problem is no longer being consciously considered.

The work of all great men shows the employment of imagination; it constitutes the beginning of all great discoveries.

The author distinguishes between two types of imagination:

The first type of imagination is meditative. It acts slowly, and to a certain degree may be governed by the will. There is a second type, rather more delicate in nature, whose action is sudden and not preceded by reflection. It is this type which enables us to see at a glance all the correlations and distant consequences of a chance observation. The pre-disposing factors are impressionability and nervous sensibility. This quality varies greatly from individual to individual, certain minds respond to the slightest external suggestion, while others feel nothing, see nothing. In general, great scholars are characterized by a highly developed aptitude for sensing and using facts presented to them. . . . . The two types of intellectual activity seem to be predominantly natural endowments. Some children have wide-awake minds, others are more dull and remain thus throughout life.

As for the rôle education can play in developing this quality of imagination, we read:

Exercises in written composition, problems in geometry, afford excellent material from which to build up mental habits of using accumulated knowledge or of seeking new correlations of known facts. This type of training is doubtless the most useful function of secondary education. On the other hand, education cannot develop the second type of mental activity which is not dependent on reflection, but which functions instantly in some way not known to us. Nevertheless, there seems to be some possibility of perfecting this natural endowment by means of suitable laboratory exercises.

3. Judgment

The two qualities already discussed—imagination or intellectual activity and work or bodily activity—can be used most efficiently only when the combination is used judiciously. Three forms of judgment are discussed:

1. Common sense—which, if developed to its highest degree, becomes what Pascal has called the sense of finesse. It should guide the choice of problems to be studied.
2. Critical sense—indispensable to both scholar and to those directing industries. This gift makes possible the detection of errors in measurements or leads to a premonition against erroneous interpretations of observations.
3. The sense of subtle discrimination which enables us to guide our minds directly into domains of thought which are not perfectly obvious.

Commenting upon the development of this quality, Professor Le Chatelier says:

Good common sense is often a gift of nature, but the more delicate sense of subtle discrimination is principally a result of education. It is very rarely observed among the children of the lower grades; it is a product of classical education, and, above all, it

springs from that which is taught in the home. The English declare that thirty-six years of education are necessary to make a gentleman, twelve for the grandfather, twelve for the father and twelve for the son. The same holds true for this sense of finesse. Pascal, Lavoisier, scholars of the first rank, came from families of long-standing culture, and their successes were due in large measure to the prolonged efforts of their ancestors.

The study of classics and humanities aids in developing this trait. Literary or historical criticism requires constant evaluation of opposing points of view to determine the part played by each in domains not amenable to exact measurement. On the other hand, the study of science develops the geometrical viewpoint, *i. e.*, the use of syllogism, which is utterly useless when comparing phenomena possessing no common measure or such as are based on mere probabilities. The exclusive use of rigorous reasoning and an absolute faith in his conclusions are sometimes very dangerous to a savant. They hinder him from taking account of the real value of the hypotheses which he has made and from recognizing the possible errors in his experiments. These modes of thought are not less hazardous to the industrialist to whom they may impart an unwarranted confidence in the predictions as to the advantages of a new business venture or of a new method of manufacture.

4. Documentation

The possession of the three qualities thus far discussed—activity, imagination, judgment—are not sufficient for laying claim to a right to be numbered among the intellectual élite.

Suppose that a savage has had from birth all the qualities which we have just reviewed, but that he is entirely ignorant of the progress of the science and industry of the civilized world. It would be extremely difficult for him to advance our knowledge, for he knows nothing about such matters. He can accomplish feats which to him seem extraordinarily difficult, such as cutting flint or extracting iron from ores, just as his ancestors did. To us however, he would seem ignorant and no one would dream of classing him as a great man.

It is therefore necessary for one to be cognizant of actual conditions in order to improve one's knowledge and make innovations. Several reasons for this are:

1. In the first place, one can obviously improve only those things which he really knows. A frequent cause of the failure of inventors is that they knowingly venture into unfamiliar fields. . . . .

2. A second reason for being well acquainted with the field arises from the fact that all creative advances, all discoveries are, for the most part, the result of combining facts already known. The progress achieved by a single individual is, in general, extremely little, but among these short steps forward, one perhaps, like the last drop which causes the vessel to overflow, may make an invention realizable or it may alter the orientation of our scientific ideas. . . . .

3. A third reason for being well versed is that accomplishment of anything new demands a knowledge of the technic of the field, and this has to be learned. . . . . .

How is this knowledge of the field, essential to any worker who hopes to advance human welfare, to be acquired? Professor Le Chatelier answers as follows:

. . . through instruction furnished by schools of all grades, from the highest to the lowest, or it may be a result of observation of the facts, *i. e.*, a fruit of the direct study of the surroundings in which we live.

No one is born with a knowledge of the outer world; this must be acquired solely from experience and toil. Certain natural endowments, memory in particular, favor the acquisition of this necessary knowledge. . . . .

The sense of observation is no less valuable; it is essential to the completion of the fragmentary knowledge acquired by the memory during the years of schooling. As we go through life, we are confronted by a multiplicity of facts which demand our attention and efforts. They are so numerous that we cannot expect to learn them from books, and, furthermore, many of them are not common knowledge and consequently cannot be found in courses of instruction. Our knowledge of the world is constantly augmented by the labor of every one of us, but the contributions are extremely unequal, varying with aptitude and training. . . . .

High-school exercises in science should be largely planned to develop observational powers. Actual handling of apparatus and materials lends itself excellently to this end. A student is told to heat a material, say iodine, in a test tube, or to dissolve a substance, mercuric sulfate, for instance, in water, and then asked to describe all that he has seen. After he has completed his report, the instructor should point out all that actually can be observed in the experiment.

Conclusion

To sum up, we find that the formation of an intellectual élite entails the union of four qualities—industry, imagination, judgment, training.

Unfortunately, these qualities are, in a certain degree, contradictory among themselves. The toiler, bound to his task like an ox to a cart, often forgets to pause and meditate; his intellectual activity slows down. The dreamer, the inventor lets himself be guided by his fancies and often lacks common sense. Finally, the abuse of book learning and memory tends to paralyze all the intellectual faculties.

It is extremely difficult to produce a perfect balancing of these diverse faculties. This fact alone is sufficient to explain the infrequency of great men and, *a fortiori*, of men of genius. It is useless to suppose, as many do, that men of genius owe their accomplishments solely to exceptional natural endowments which raise them above the common level. They have qualities which taken singly are not extraordinary, but it is the occurrence of all these qualities in a single mind that is rare.

Most men do not like to work. . . . . Intellectual industry is not much more common than bodily industry. . . . . Common sense is perhaps rarer still. . . . . Finally, the question of learning what has been done and the matter of instruction and training is still in a precarious condition. . . . .

Admitting what has been said, let us make a calculation. Suppose one man in ten has a love of industry; one in ten a certain intellectual activity; one in ten common sense; one in ten has been well taught. The probability that these four qualities will be found in one individual will be $(1/10)^4$ or $1/10,000$, *i. e.*, one in ten thousand may be expected to belong to the intellectual élite. This is not many. The production of a great man requires the union of these same qualities, but each in full bloom. If each quality, developed to this high degree, occurs in one man in a hundred, the probability of their being thus present in a single individual is $(1/100)^4$ or one in a hundred million. Consequently, we can explain why men of genius are so rare, without seeking the reason in the realms of wonder.

It is a very noble task to aid in the creation of an intellectual aristocracy. The prosperity and lasting glory of any country, all its future welfare, depend on the success of these efforts. Above all, this is a work of education, and no effort should be spared to realize this common good. The family should set a good example to the younger children and inculcate a taste for toil; the secondary school must develop imagination and common sense; and finally the college and universities must impart training.

However, an intellectual élite is not the only thing required to make a great nation. There must also be a moral élite, a great class which knows respect for the rights of others, a class to whom the Golden Rule is law, and last but not least, this class also respects and demands respect for real liberty. . . . . We have a right to expect that the educated classes will have both a highly developed sense of duty and a profound appreciation of independence. It is their duty and privilege to set a noble example to others.

M. W. G.

Towns' Gas from German Lignite. Experiments are being conducted in Kassel, the object of which is to ascertain if lignite, or soft coal, is suitable for the production of gas that can be used for domestic and industrial purposes. The Chief Burgomaster, Dr. Stadler, stated that the owners of hard-coal mines in the Ruhr district had united to form a company which intended to supply the whole of the Rhineland and Westphalia, and ultimately adjacent provinces, with gas produced at the pitheads and conveyed to the consumers by an elaborate system of underground mains, so as to do away with uneconomical gas works. The German lignite industry thereupon also resolved to ascertain if gas of good quality could be obtained from their product and distributed to distant consumers. They therefore constructed special experimental gasworks at Kassel capable of supplying a town of 20,000 to 30,000 inhabitants. A special laboratory has also been constructed and equipped for testing lignite gas taken from mains as well as all the properties of the subsidiary products. At the commencement lignite briquets are to be used, but later it is proposed to supply dried soft coal to the ovens, and ultimately it is hoped that it will be possible to use soft coal as it comes straight from the mines.—*Chem. Age*, **20,** 19 (Jan. 5, 1929).

Firedamp Explosions. As the result of investigations previously carried out by the Safety in Mines Research Board, means have been devised to allow for complete or partial release of the pressure developed by firedamp explosion within closed vessels, such as the casings of electric switchgear, and at the same time to ensure that the flame of the explosion shall not pass from the casing to the atmosphere outside. Experiments carried out by Beyling in Germany have suggested, however, that, when the casings are divided into inter-communicating compartments by partitions, the ignition of an explosive mixture in one compartment might result in considerably enhanced pressure being produced in the other. An account of an investigation into this possibility is contained in a paper entitled "Firedamp Explosions within Closed Vessels: 'Pressure Piling,'" by C. S. W. Grice and R. V. Wheeler (Safety in Mines Research Board Paper No. 49, published by H. M. Stationery Office, price 1s. net). The research has shown that if an explosion of firedamp and air is allowed to propagate from a casing of comparatively large volume through a narrow opening into a casing of comparatively small volume, pressures considerably above the normal are very rapidly produced.—*Chem. Age*, **20,** 98 (Feb. 2, 1929).

ABSTRACTS

TEACHING METHODS, AIDS, APPARATUS, AND SUGGESTIONS

An Efficient Stirrer for Gas Absorption. A. F. BENNING. *Proc. Ind. Acad. Sci.*, **37**, 263 (1927).—"The most convenient way of increasing the rate of absorption of a gas in a liquid is to increase the surface of contact between the two. There are many ways of doing this, but the most of them are not applicable to laboratory work.

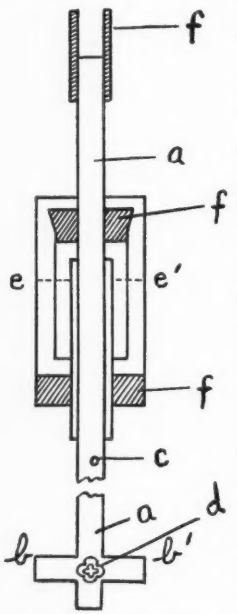
"An efficient and simple way of increasing this surface of contact is to use a stirrer designed to distribute the gas throughout the liquid in the form of fine bubbles, or, better still, atomize the liquid in the presence of the gas.

"An easily constructed stirrer for this purpose can be made by sealing two short glass tubes *bb'* (see Figure) close to one end of a straight piece of glass tubing *a* long enough to serve as a shaft for the stirrer. The end of *a* below *bb'* is just long enough to reach the liquid when the stirrer is rotated with the arms *bb'* just free of the surface. The upper end of the shaft *a* is closed and a small hole is blown in the lower part to permit the entrance of the gas. The junction of the four tubes is constricted so that the cross-section is smallest at that point, *d*.

"If this stirrer is rotated with the arms under the surface, the liquid will flow from the lower tube to the ends of the arms. Because of the contraction at the junction and the friction loss at the liquid entrance, the pressure at the center of the arms is reduced, drawing gas down the shaft through the hole *c*. The liquid and gas are forced out the ends of *bb'*, resulting in the gas being distributed through the liquid in the form of fine bubbles.

"If the stirrer is raised so the arms are just free of the surface, gas will be drawn from the hole in the shaft and liquid through the lower tube; the two will be intimately intermixed and sprayed throughout the gas space in the containing vessel. This provides an enormous contact surface with a corresponding absorption rate.

"In practice this stirrer must be rotated at a fairly high rate of speed, and to prevent vibration, or rather to allow the stirrer to align itself, it should be flexibly connected with the driving mechanism. This can best be arranged by connecting the shaft with the driving axle by means of a short piece of pressure tubing. If a mercury seal is used, as is generally the case, all of its moving parts should be flexibly connected with the shaft by means of a rubber stopper or similar flexible joint.

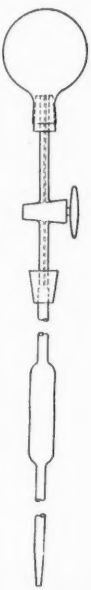


CONSTRUCTION OF THE STIRRER

a—Shaft; *bb'*—Stirring arms; *c*—Gas entrance; *d*—Constricted junction; *ee'*—Mercury level; *f*—Rubber connections.

"In one particular case it was found that a stirrer of this type reduced the time of absorption from 28 to 3 hours." M. W. G.

A Pipet for Measuring Corrosive and Toxic Liquids. *Synthetic Org. Chemicals*, **2**, 2 (Dec., 1928).—"The organic chemist frequently has occasion to measure out accurately materials like acetyl chloride, acetic anhydride, or phosphorus trichloride which cannot always be weighed easily. A more convenient method of measurement is to use a pipet, since this avoids exposing large surfaces of liquid to the air. The attachment shown in the diagram has been found very useful in this connection as a source of suction for the pipet. After a little familiarity with its manipulation, volumetric measurements can be made quickly and accurately using this device.



"The parts required are usually available in the laboratory. They consist of a rubber bulb from a storage battery hydrometer, a short

capillary glass tube fitted with a stopcock, and two rubber stoppers. The accompanying diagram shows the details of assembly, which need little explanation.

"When ready for use, the pipet is attached and the rubber bulb depressed with the stopcock open. After inserting the point of the pipet into the liquid, the bulb is released and the liquid allowed to rise to the desired level. When it reaches the calibration mark, the stopcock is turned to the horizontal position and the pipet removed from the liquid. If normal emptying time is required for accurate measurements, the lower stopper is removed, allowing the liquid to flow out freely. If a slower outflow is needed, the rubber bulb can be removed and the time of emptying controlled by the stopcock.

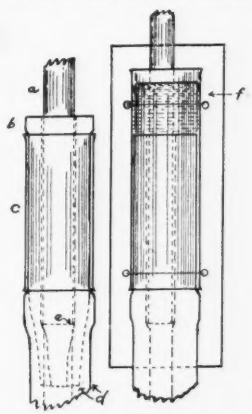
"This method of drawing up liquids has been found to be much more satisfactory than using suction from a vacuum line.

"By replacing the stopcock described by the usual two-way stopcock, it becomes unnecessary to detach the pipet in order to allow the liquid to run out. It will be possible for the liquid to drain under its own head by turning the cock so that the pipet is connected with the outside air." G. B. C.

Laboratory Hand Grenade Fire Extinguisher. *Laboratory*, **2**, 11 (1929).—A very effective fire extinguisher can be cheaply made in any laboratory. To make these, take some old electric light bulbs, those with the sealing tip on the top. Immerse the tip under the surface of some CCl_4 in a wide container and with a pair of pliers snap off the glass tip. The evacuated bulb draws in CCl_4, practically filling itself. The bulb is then placed in an upright position and the tip sealed with litharge and glycerine. The bulb is then a complete fire extinguisher. Several can be placed on a small wooden rack made by drilling a few holes to accommodate the bulb bases.

To use—merely "grab" a bulb from the rack and hurl it directly into the midst of the fire. The bulb breaks, letting loose a flood of CCl_4 in the heart of the flames. G. B. C.

A Clamp for Rubber Tubing. H. W. BATCHELOR. *Ind. Eng. Chem.*, **20**, 366 (April, 1928).—"The following method of clamping rubber tubing to glass tubing for general laboratory apparatus or for pressure or vacuum systems has been found very satisfactory.



"A sleeve, approximately $1\frac{1}{2}$ inches (3.8 cm.) long may be made of thin glass tubing whose inside diameter is but slightly larger than the outside diameter of the tubing to be used. The sleeve is first slipped several inches on the rubber tubing. The tubing is then slipped into place on the glass tubing, *a*. While holding both the glass and the rubber tubing at *b*, the latter is stretched slightly so that it assumes the position indicated by the dotted lines at *d*. The glass sleeve is then put in position and the rubber tubing worked back into position as shown by the heavy lines at *d*.

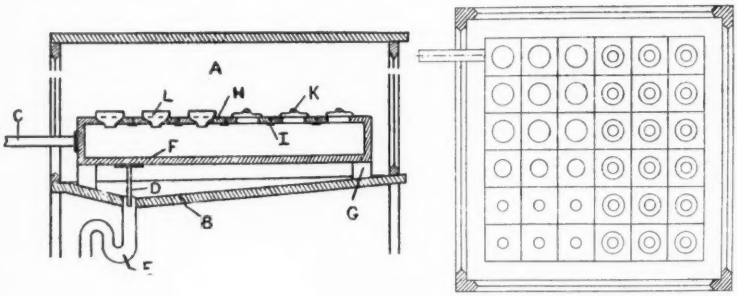
"When the rubber tubing has been properly worked into position, the clamp is so effective that it is practically impossible to remove the tubing when pulling at *b*. By stretching the tubing again at *d* and removing the sleeve, the two tubes can be easily separated again. Though not usually necessary, the clamping effect may be increased by slightly widening the end of the glass tubing at *e*.

"If the clamp is used in the construction of gas-analysis apparatus, a mercury seal would scarcely be necessary, since the rubber tube is clamped uniformly throughout its circumference. The clamp may be modified, however, to form a cup for a mercury seal as shown at *f*.. A mercury seal to connect two rubber tubes can be easily prepared by welding a side arm at the midpoint of the sleeve. Such a cup can be used either with a straight side arm in a horizontal position or in a vertical position with the side arm bent to a vertical position.

"The sleeve also affords an excellen tprotection for the rubber tubing if it is necessary to wire it in position on a base as shown. It is hoped to make available in the near future either metal or other tubes for this purpose." M. W. G.

A Practical, Inexpensive and Durable Laboratory Evaporator. P. OERTEL. *Chem.-Ztg.*, **52**, 302 (April 14, 1928).—The evaporator described can be worked at pressures of 0.2 to 0.5 atmosphere, and operated at an average temperature of 85°C., the maximum

temperature attained being 95°C. Thus, the material can be evaporated without spattering. The design of the apparatus is such that little corrosion takes place and the



CROSS-SECTION VIEW TOP VIEW

A—Hood; *B*—Sheet lead bottom; *C*—Steam inlet valve; *D*—Steam exhaust; *E*—Sewer outlet pipe, soldered to *B*; *F*—Sheet iron bottom and sides (0.5–2 mm. thickness); *G*—Wooden supports (10 cm. high); *H*—Baked clay slabs, cemented together with a mixture of cement and waterglass; *I*—Angle iron supports; *L*—Containers for liquid to be evaporated; *K*—Covers for openings not in use.

solutions being evaporated cannot be contaminated with the product of the corrosion of the bath. For better keeping qualities, the iron parts are painted with asphalt.

M. W. G.

A New Device in Glass Apparatus. E. I. LEWIS. *Chem. & Ind.*, **47**, 1238–41 (Nov. 23, 1928).—The author describes and illustrates a device by which carefully ground units, similar to the ball and socket type, are held together either by a thin film of lubricant or by a screw clamp, forming a gas tight but flexible joint. The elements may be glass of different kinds, porcelain or stoneware or other material, but all are ground to the same curvature so as to be interchangeable with units of other material.

E. R. W.

Safety Tongs for the Laboratory. *Laboratory*, **2**, 5–7 (1929).—Tongs for the convenient handling of beakers, flasks, evaporating dishes, and casseroles have been devised. These safety tongs are offered in sets of four which consist of:

Safety Beaker Tong with which any Griffin form beaker having a capacity from 100 ml. to 1500 ml. can be firmly gripped and safely tipped without danger of burns from the hot beaker or scalds from its contents.

Safety Flask Tong with which any Erlenmeyer flask, 125 ml. to 1000 ml. capacity, can be safely handled. Also flasks of other shapes taking No. 4 to No. 10 rubber stoppers can be grasped with this tong. Its use enables hot and corrosive liquids to be poured from flasks without having the liquids drip on the fingers.

Safety Dish Tong with which hot evaporating dishes having diameters from 75 to 120 mm. can be safely handled. The use of this tong enables the contents of a dish to be poured without spilling, or the dish can be inverted and the precipitate brushed out.

Safety Casserole Tong with which hot porcelain casseroles (Coors Sizes No. 1 to No. 5 inclusive) can be safely handled and their contents poured.

Each tong is made of Ascaloy, a stainless chromium iron alloy which is rust and chemical resistant.

G. B. C.

The Bulletin Board as a Teaching Aid. G. P. CAHOON. *Sch. Sci. & Math.*, **28**, 867–73 (Nov., 1928).—A discussion of the problem of utilizing the wealth of science material in current periodicals with suggestions for checking and clipping, filing, mounting, titling, grouping, and use of articles of interest and value to science students.

B. H. B.

Mathematical Problems in General Chemistry. W. G. BOWERS. *Sch. Sci. & Math.*, **28**, 975–80 (Dec., 1928).—Author discusses development of use of problems in chemistry and concludes that mathematics used in elementary chemistry should: (1) be as simple as possible; (2) deal only with gas volume relations, and reacting quantities; (3) contain enough problems necessary to drive home and make practical each

variety of chemical reaction; (4) be taught to develop a knowledge of chemistry rather than mathematics. B. H. B.

Taking Stock in Chemistry Classes at Mid-Year. J. O. FRANK. *Sch. Sci. & Math.*, **29,** 39–43 (Jan., 1929).—Author advises teachers to renew and reconsider accomplishments of first semester and evaluate prospects of accomplishing objectives by end of second semester.

Accomplishments may be considered under: (1) instruction; (2) inspiration; (3) discipline; (4) power to interpret; (5) explanation and guidance; and (6) recreation.

Problem of preventing "let down" in second semester may be met by making work a challenge of student's ability but not discouragingly hard and by introducing new fields of subject matter as fast as the students can understand and assimilate them. Author makes a plea for qualitative analysis as a part of second semester laboratory work. B. H. B.

A Method for Using History of Chemistry as a Teaching Aid. I. W. WADE. *Sch. Sci. & Math.*, **28,** 877–80 (Nov., 1928).—Author outlines following plan for use of History of Chemistry. At beginning of 2nd semester each student was assigned the name of one outstanding chemist and held responsible for information on: (1) life; (2) education; (3) work in chemistry; (4) influence on contemporaries and development of chemistry.

Above topics covered by oral report in classroom and written report at the end of school year. Chemists were so selected as to help develop course and pictures, photographs, etc., were collected and used as aids. Author finds best introduction to an abstract science to be through study of lives of those whose work it is. B. H. B.

The Structure of the Nucleus of the Atom. W. D. WALKER. *Sch. Sci. & Math.*, **28,** 936–9(Dec., 1928).—Author submits outline used in course on atomic structure. B. H. B.

Experiments in Teaching Students How to Study. G. M. WHIPPLE. *J. Educ. Res.*, **19,** 1–12 (Jan., 1929).—See Chemical Digest, THIS JOURNAL, **6,** 561 (Mar., 1929). R. M. P.

KEEPING UP WITH CHEMISTRY

Manufacture of Carbon Dioxide. H. E. HOWE. *Ind. Eng. Chem.*, **20,** 1091–4 (Oct., 1928).—A description of the method employed in the new plant of the Dry Ice Corporation, having a capacity of thirty tons per day and believed to be the largest plant for this purpose in existence. The CO_2 is produced by burning low sulfur coke, the stack gas containing 16–18 per cent CO_2. The heat is used to operate compressors and supply heat needed in the process. The gases are scrubbed with water and the SO_2 is removed with limestone. The gases pass through absorption towers where the CO_2 is absorbed by a $2^1/_4$ normal sodium carbonate solution. The original solution contains 7–8 pounds sodium carbonate per cubic foot, and after absorption three pounds sodium carbonate and about six of sodium bicarbonate. The residual gas consists of nitrogen and about eight per cent CO_2 which cannot be recovered economically at the temperature of the absorption tower which is 120°F. The solution is then led to the boilers where the CO_2 is liberated by boiling at 240°F. at a pressure of about eight pounds. The gas is cooled to remove the water, compressed, and liquefied. On allowing it to expand, part of it solidifies, and it is then pressed into blocks and is ready for the market. D. C. L.

Explosive Properties of Solid Hypochlorites. J. WEICHHERZ. *Chem.-Ztg.*, **52,** 729–30 (1928).—Pure calcium hypochlorite with 70% of available chlorine evolves oxygen slowly at temperatures below 100°, but explodes violently with liberation of its oxygen content at 112°. Mixtures of the hypochlorite with organic substances such as alcohol, tars, mineral oils, or starch are stable at ordinary temperatures, but, on warming, deflagrate, sometimes with explosive violence. Similar effects are obtained by contact with moisture, but in this case there is a more or less lengthy period of induction depending on the nature of the organic substance. M. W. G.

Industrial Mold Fermentations. O. E. MAY. *Hexagon of Alpha Chi Sigma*, **19,** 125–30 (Dec., 1928).—During the war, when little attention was paid to costs, several fermentations were developed and put into industrial operation. More recently fungi seem to offer industrial possibilities. Their use in the manufacture of cheese, soy sauce, certain beverages, and their action in the disintegration of organic débris have long been appreciated. Certain different fungi acting on sugar solutions under different conditions produce citric, oxalic, formic, gluconic, malic, succinic, acetic, and other acids; also alcohol, cholesterol, fats, and various pigments. Certain fungi are capable of transforming carbohydrates into ethyl alcohol until the concentration is

about 25 per cent, and a French company is reported to be producing alcohol by mold fermentation. The chief difficulty lies in preventing infection by other organisms as it functions at a p_H of 7.0. The most promising field appears to be in the production of organic acids, which can be produced at high H-ion concentrations where few yeasts and bacteria can survive. Citric acid is produced commercially from sucrose, requiring about ten days. About 170 different strains of fungi have been investigated by the Department of Agriculture and a method for the production of gluconic acid has been developed. It is believed by many investigators that a process involving double fermentation will be successful in converting cellulose into alcohol for power purposes, first inoculating with a fungus to hydrolyze the cellulose and then fermenting these products. D. C. L.

Chemical Preparations for War. Recent Progress in the Applications of Chemistry to the Art of Destruction. A. LAVOULE. (From *Revue des Vivants*, Paris.) *Living Age*, **335,** 244–7 (Dec., 1928).—The author thinks that "intensive work is now being carried on by the great nations of the earth so that the next war may be short, sharp, and characterized by unprecedented destructiveness." T. B. D.

Thermometers and New Wells. *Tycos*, **19,** 31 (Jan., 1929).—Apparatus for recording ground temperatures as an aid in determining the location of prospective oil wells has been developed by A. J. Carlson, petroleum engineer, at the University of California.

The temperature in wells over reservoirs of oil increase more rapidly than in wells barren of oil. By watching the rate of increase in temperature during the first few hundred feet, oil well drillers may be saved much expense and trouble in sinking wells. E. L. M.

Symposium on Chemistry and the Food Industries. *Ind. Eng. Chem.*, **20,** 1286–1325 (Dec., 1928).—The titles included are: Chemistry and the Canning Industry, W. D. Bigelow, 1286–9; Chemistry and the Beverage Industry, F. M. Boyles, 1289–92; Chemistry and the Baking Industry, C. B. Morrison, 1292–4; Chemistry and the Cocoa and Chocolate Industry, F. C. Gephart, 1295–7; Chemistry and the Preserve, or Jam and Jelly Industry, C. P. Lathrop, 1298–301; Relation of Chemistry to the Citrus Products Industry, C. P. Wilson, 1302–7; Chemistry and the Flavoring Extract Industry, B. H. Smith, 1307–9; Chemistry and the Shortening Industry, M. B. Graff, 1309–12; Chemistry and the Dairy Industry, G. E. Holm, 1312–5; Relation of Chemistry to the Spice Industry, J. Glassford, 1316–7; Chemistry and the Breakfast-Food Industry, W. S. Hilpert, 1318–9; Chemistry and Food Regulation, P. B. Dunbar, 1320–2; The Service of Chemistry to the Milling Industry, C. O. Swanson, 1322–4; Research in the Confectionery Industry, H. S. Paine, 1325–7.

These articles are accompanied by illustrations and valuable bibliographies. M. W. G.

Solutions. T. M. LOWRY. *Chem. & Ind.*, **47,** 1233–8 (Nov. 23, 1928); 1260–5 (Nov. 30, 1928).—The Messel Memorial Contribution. A thorough and scholarly treatment of the phenomena connected with the dissolving of sugar, salt (sodium chloride), and sulfuric acid in water. Many references to the original literature are given. E. R. W.

Activated Carbon; Some Industrial Applications. J. T. STRACHAN. *Chem. & Ind.*, **47,** 1203–14 (Nov. 16, 1928).—The article contains a brief history of the development of activated carbon and an outline of the different methods by which it is now produced. The use of this material in gas masks, in the industrial recovery of vapors, and in the purification of oils, fats, sugar, and other materials is discussed. E. R. W.

Second International Conference on Bituminous Coal. R. E. GILMORE. *Can. Chem. & Met.*, **12,** 335–41 (Dec., 1928).—"Contains a complete list of papers given at the Conference at Carnegie Institute and contains abstracts on Origin and Classification of Coals, Carbonization of Coal, Synthetic Liquids by the Conversion of Hydrocarbons, Coal Cleaning and Purification, Pulverized Fuel and Its Use in Internal Combustion Engines." D. C. L.

Coal—Cinderella of Chemical Industry. H. J. ROSE. *Chem. & Ind.*, **47,** 1301–4 (Dec. 14, 1928).—"Coal has been discovered three times: (1) as a raw fuel for heat and power; (2) as a source of coke and gas; (3) as a chemical raw material. The discussion of these uses, especially of the third, is interesting and instructive." E. R. W.

Twenty-Five Years of Biochemistry. H. PRINGSHEIM. *Science*, **68,** 603 (Dec. 21, 1928).—A short review of progress during the twenty-five year period. Mainly devoted to sugars, fats, and proteins. G. H. W.

Radium in Rocks: I. The Radium Content of Some Representative Granites of the Eastern Seaboard of the United States. C. S. PIGGOT. *Am. J. Sci.*, **18,** 13–7 (1929).—

A report of an investigation undertaken to determine the radium content of characteristic and typical examples of the principal rock groups in widely separated localities. With the information obtained it is hoped that the geological circumstances of the rock's occurrence might be deduced, and that the chemical and petrographic characteristics might be correlated with the radium content. An apparatus and procedure has been described which is satisfactory for determining the radium content of ordinary rocks. The amounts of radium per gram of rock found in granites occurring along the eastern seaboard varied from 0.378 to 4.826 $\times 10^{-12}$ g. G. B. H.

The Production and Uses of Beryllium. K. ILLIG. *Can. Chem. & Met.*, **12**, 310–3 (Nov., 1928).—Beryllium was discovered in 1798 by Vauquelin in the mineral "beryl," which had been known since antiquity. The word beryl is the root of the German word "Brille" (eye-glasses), for the reason that Nero possessed a kind of a monocle made from a piece of polished optically clear beryl. In 1828 Wöhler first prepared metallic beryllium in small glistening masses by the action of potassium metal on beryllium chloride.

The attempts of various early investigators to isolate the metal satisfactorily are reviewed. The work of Stock and Goldschmidt on the electrolytic separation of the metal from a fused salt mixture is given in more detail, since this is the basis of the present-day commercial production of beryllium. The occurrence of beryl, the various beryllium alloys with outstanding properties of each, and the future prospects for this metal are other topics included. D. C. L.

The Extraction and Utilization of Cobalt. G. M. DYSON. *Chem. Age, Mo. Met. Section*, **19**, 33–5 (Nov. 3, 1928) and 41–2 (Dec. 1, 1928).—"The history of the element cobalt appears to be intimately bound up with the early German mining legends. The majority of textbooks have it that the word 'cobalt' is derived from the German 'Kobold,' but, in reality, the nearest approach to 'cobalt' found in the writings of the ancients (Paracelsus, Agricola, and 'Basil Valentine') is the word 'cobalus,' which was the name of a spirit that, according to the superstitious notions of the times, haunted mines, destroying the labors of the miners, and often giving them a great deal of unnecessary trouble. In fact, at one time it was customary in Germany to incorporate into the Church service a prayer that 'God would preserve miners and their works from kobalts and spirits.' The name cobalt, then, became gradually associated with any mineral which from its appearance contained metal, but from which no metal could be extracted. It is not clear whether, in the first place, the miners actually associated the refractory nature of the minerals with the presence in them of a gnome, or whether they gave this name to the mineral out of joke, because it thwarted them as much as the supposed spirit."

The various topics treated in this article are: distribution and extraction of Co, methods of separating Ni and Co, properties of Co, the ferrous and non-ferrous alloys, Co compounds and uses in ceramics. M. W. G.

Aluminum Alloys. *Can. Chem. & Met.*, **12**, 349 (Dec., 1928).—"A report of an address given by R. S. Archer of the Research Bureau of the Aluminum Company of America. Gives the history of the developments in the aluminum industry with the properties and uses of the pure metal and when alloyed with other metals." D. C. L.

Modern Baking Powders. R. M. LADD. *Can. Chem. & Met.*, **12**, 308–9, 323 (Nov., 1928).—The constitution, manufacture, and baking properties of various types of mixtures are discussed. D. C. L.

Sources of the Common Aliphatic Alcohols. *Synthetic Org. Chemicals*, **2** (Dec., 1928).—The first alcohols produced commercially from petroleum products were obtained from the unsaturated hydrocarbons. By selective absorption in sulfuric acid and hydrolysis of the alkyl acid sulfates, ethyl alcohol, isopropyl alcohol, secondary *n*-butyl and *n*-amyl alcohols are produced.

Special cracking produces *iso*-butylene and iso-amylene from which tertiary butyl and tertiary amyl alcohols are formed.

Pentanes from casing head gasoline are chlorinated and then hydrolyzed. *N*-amyl alcohol, *iso*-amyl alcohol, secondary amyl alcohol, tertiary amyl alcohol, secondary butyl carbinol, and diethyl carbinol are formed in this way.

West Virginia natural gas is a source for ethylene glycol, propylene glycol, ethyl alcohol, and *iso*-propyl alcohol.

Fermentation processes yield ethyl alcohol, *n*-propyl alcohol, *iso*-butyl alcohol, *iso*-amyl alcohol, and secondary butyl carbinol.

The Grignard reaction and reduction of esters with sodium and alcohol yield other alcohols, such as, *n*-octyl, lauryl, myristyl, *n*-hexyl, and *n*-nonyl alcohols.

Special synthetic processes yield methanol and ethanol. Also cetyl alcohol, allyl alcohol, and others are prepared by special methods. G. B. C.

These Ultra-Violet Rays. E. E. FREE. *Harper's*, **158,** 338 (Feb., 1929).—The sun-ray worshippers of 1928 need not journey to open hillside temples or build solaria in which to lure the sun. Thanks to artificial sun-ray lamps the modern devotee can snap his God on or off with a switch. Many of these lamps are more powerful than the summer sunlight at noon. The first lamps were made by passing electricity through mercury in a quartz tube. Later it was found the common carbon arc light also produced them. If the carbons are impregnated with cerium, iron, or other elements, the arc will emit still more ultra-violet rays. All these lamps can do harm if not used properly. Many of the cheap lamps on the market are only overgrown electric lights and emit only heat.

The invention of the lamps sprang from discoveries concerning the rays. Ultra-violet rays have been found to cure rickets either by direct action on the body or by applying them to the food to be taken later by the rickety child. The rays produce an activated chemical (vitamin) which does the work. The same vitamin is found in cod-liver oil.

Other cures effected are bone tuberculosis; pulmonary tuberculosis; and arthritis. The action here is regarded as germicidal.

As ordinary window glass cuts out practically all these rays from the sun, other glasses have been developed for house use. Most of these deteriorate in time with the exception of pure fused quartz, which is very expensive. Smoke is a worse obstacle to city dwellers than window glass. J. W. H.

Nature's Great and Small and Man's Measurement of Both. Part I, Mass. W. T. SKILLING. *Sch. Sci. & Math.*, **28,** 858–63 (Nov., 1928).—"Man stands midway in the universe. Through a telescope he looks up at the vastness of nature and through a microscope he looks down at its minuteness. The two vistas are of nearly equal extent and complexity." Thus the author introduces his comparison of differences and similarities of the structure and functioning of the stars and solar systems, and the atom with its nucleus and planetary electrons. Methods used to determine weights and velocities are briefly outlined. B. H. B.

Nature's Great and Small and Man's Measurement of Both. Part II, Radiation. W. T. SKILLING. *Sch. Sci. & Math.*, **28,** 959–65 (Dec., 1928).—Using notes of piano as comparative measures author shows relation of radio, heat, light, ultra-violet light, x-rays, gamma, and cosmic rays. Measurements of wave-lengths by means of gratings and crystal gratings and relationships of vibration rate, velocity, and wave-length are briefly mentioned. Some effects of extremes of temperature, methods of measuring temperature, possible temperature effect on inner structure of sun and stars and in "stripping" atoms are also mentioned. B. H. B.

A New Method for the Preparation of Cuprous Sulfate. J. G. F. DRUCE. *Chem. News*, **137,** 385–6 (Dec. 21, 1929).—"Cuprous sulfate itself was first prepared in 1909 by Recoura [*Compt. Rend.*, **148,** 1105 (1909)] who obtained it by the interaction of methyl sulfate and cuprous oxide at 160°C.

"We have now obtained it in a more simple manner by the interaction of copper and concentrated sulfuric acid:

$$2Cu + 2H_2SO_4 = Cu_2SO_4 + 2H_2O + SO_2.$$

"We have found that the best yield of cuprous sulfate is obtained by carrying out the reaction between 180–220°C. Concentrated sulfuric acid is heated to about 200° and copper turnings are added. There is a violent reaction and some sulfur dioxide is d sengaged. Most of the cupric sulfate formed sinks to the bottom of the liquid in the anhydrous condition. It has been stated that cupric sulfate is insoluble in concentrated sulfuric acid. This salt is not present at this temperature in any quantity, however, so long as any metal remains undissolved. The acid assumes a bright emerald green color unless black cuprous sulfide is produced, which masks it. While still hot the mixture is filtered through a small wad of asbestos into a mixture of equal volumes of dry alcohol and ether which removes the excess of acid. As the filtrate drops into the organic liquid, crystals of cuprous sulfate separate out. These are left on decanting the liquid and are washed with the solvents, drained and dried in a vacuum desiccator.

"On analysis 0.2780 g. of the substance gave 0.3071 g. $BaSO_4$, or 45.5% SO_4; Cu_2SO_4 requires 42.87%."

Additional attempted methods of preparation are discussed briefly, properties of the cuprous sulfate listed, and references given to work of other investigators.

M. W. G.

Standard Method for the Analysis of Ferrocyanides. ANON. *Chem. & Ind.*, **47**, 1308–10 (Dec. 14, 1928).—The advantages and disadvantages of the common methods for the analysis of the ferrocyanides are discussed. The list includes those involving conversion to hydrocyanic acid, oxidation methods, and titrations using the salt of a heavy metal. The technical staffs of the European Prussiate Manufactures have agreed that the titration method using zinc sulfate is the best yet offered. The composition of the compound formed is constant and agrees with the formula $Zn_3K_2(Fe(CN)_6)_2$. A 15% solution of pure iron alum is used as the indicator. The method of procedure is given in detail. E. R. W.

Hydrogen-Ion Measurements in the Pulp and Paper Mill. W. F. HOFFMAN. *Dyestuffs*, **29**, 184–7, 192 (Dec., 1928).—Conclusion of article begun in *Dyestuffs*, **29**, No. 11. See THIS JOURNAL, **6**, 390 (Feb., 1929). A. E. C.

The Relation of Research to Wealth Production. H. E. HOWE. *Science*, **68**, 495 (Nov. 23, 1928).—"Wealth is produced by the performance of work upon the materials of nature as we find them on and in the earth's crust. In the term work is included not only the actual physical work done by men and machines, but also the work performed by capital, and this includes the use of money and of the facilities which money purchases. Wealth then represents an accumulation of something above actual requirements for maintenance and is usually represented by some form of money or negotiable exchange.

"While for the purposes of discussion wealth may be taken in this case as something measured by dollars, nevertheless the less tangible but equally important contributions of science to things cultural and even spiritual must not be overlooked, and because of these factors a complete evaluation of the contributions of science is well-nigh impossible.

"It is doubtless true that through the contributions of science the average individual today has an amount of leisure far beyond that experienced at any other period of the world's history, and an increase in leisure is almost directly in proportion to the contributions which science makes in the perfection of industrial processes and means for doing the world's work. Indeed, many hold that the vital problem of our times is the manner in which this additional leisure is to be invested, and we progress or retrogress as we employ this leisure constructively or destructively."

Numerous examples of industrial results of research are given. G. H. W.

HISTORICAL AND BIOGRAPHICAL

Theodore William Richards. G. P. BAXTER. *Science*, **68**, 333–9 (Oct. 12, 1928).—Richards' scientific career. M. W. G.

C. S. Hudson, Willard Gibbs Medalist for 1929. J. W. E. GLATTFELD. *Chem. Bull.*, **16**, 7 (Jan., 1929).—A short historical sketch of the development of carbohydrate chemistry is given including a few of the outstanding workers in this field.

Especial attention is given to the Gibbs Medalist for 1929, C. S. Hudson. His work upon the relation of rotatory power to structure among the carbohydrates and his isolation of two new pentacetates, derivatives of galactose, are discussed. E. L. M.

The Nobel Prizes and Their Founder. N. HEDIN. *Living Age*, **335**, 294–7 (Dec., 1928).—An account (illustrated) of Alfred Nobel and the prizes awarded from this foundation. T. B. D.

The Added Years—Pasteur's Career. E. R. DOWNING. *Sch. Sci. & Math.*, **28**, 813–28 (Nov., 1928).—An inspiring article introducing a brief account of the life and work of Louis Pasteur as one of the scientists who contributed largely to the increase in man's expectation of life. Material is submitted as the type of subject matter to be used in developing or strengthening desirable traits in students and thus establishing ideals of profound influence in their lives.

Pasteur's life and training is briefly sketched and then his career as a teacher and investigator. Author stresses Pasteur's perseverance and service to his fellowmen in the various research problems he undertook and the grateful acknowledgment of the French nation in voting him their best beloved citizen. B. H. B.

Three Lives in One—David Starr Jordan. F. J. TAYLOR. *American*, **107**, 22 (Jan., 1929).—An interesting biographical sketch of the life of David Starr Jordan, in which he is characterized as the "Grand Old Man of Science and Education and a Crusader for peace when peace was unfashionable." B. C. H.

The Discovery of the Gas Laws. I. Boyle's Law. W. S. JAMES. *Sci. Progr.*, **23**, 263–72 (Oct., 1928).—Historical. A. E. C.

EDUCATIONAL MEASUREMENTS AND DATA

The Correlation between Measures of Mental Ability and Measures of Achievement in Chemistry. S. R. POWERS. *Sch. Sci. & Math.*, **28,** 981–6 (Dec., 1928).—Article reports correlation between scores on intelligence, and various measurements of achievement in chemistry. Achievement measures include scores on so-called standardized chemistry tests, teachers' marks, and marks on New York Regents Examination.

The data obtained seem to suggest but little relationship between measures of mental ability and achievement obtained from the use of these tests and author suggests some possible interpretations and reasons. B. H. B.

A Study of Difficulties in Chemistry. A. R. STEWART. *Sch. Sci. & Math.*, **28,** 828–49 (Nov., 1928).—Author divided group of 80 students of chemistry into two sections according to I. Q. (Terman Test Form A) for: (1) study of difficulties of students in chemistry; (2) to make an analysis of errors; (3) to suggest methods of overcoming difficulties. I. Q. ranged from 88–129 with a median of 109. 27 of students had not had any science previously but all others had taken physics and some had taken general science, and biology also.

Procedure was by questionnaires, concerning difficulties and their remedies given to students at end of first semester and again at end of the year, and also by tests.

Results ranked difficulties as follows—problems, equations, formulas, etc. Usual difficulty in applying mathematics to % composition, proportion, etc., were observed.

Remedies suggested are—teach less material, use material better adapted to interest of pupil, insist on more study, give more individual help, correlate laboratory and classwork more closely, give frequent objective tests, and section according to I. Q. B. H. B.

Some Functions of New Type Tests. S. R. POWERS. *High-Sch. Teacher*, **4,** 394–5 (Dec., 1928).—Tests should stand or fall in terms of whether or not they make it possible to render the children a higher quality of service.

Schools, as now administered, find their reports, which are measurement compilations, eagerly studied by both pupils and parents. Any movement which increases the certainty or accuracy of such measures is highly important. New type tests are suggested as capable of reducing inaccuracies often apparent in ratings based upon the less refined requirements of old type examinations.

These tests, as in fact any tests, when used discerningly reveal the strength and weaknesses of the teacher's work, and so improvement in teaching is stimulated. Helps for the teachers interested are suggested. Two books should be studied carefully by every high-school teacher who is interested in improving his work and in rendering a fuller service. Percival M. Symonds, "Measurement in Secondary Education," Macmillan, **1927.** Ruch and Stoddard, "Tests and Measurement in High-School Instruction," World Book Company. B. C. H.

The Use of "None of These" in Multiple Choice Questions. L. C. ELLIOTT. *Sch. Sci. & Math.*, **28,** 896–8 (Nov., 1928).—Author calls attention to wider possibilities of multiple choice questions if one of possible choices is "none of these." Also how the "give away" effect of the correct choice in some questions can be obviated by substitution of "none of these." B. H. B.

Character and Value of Existing Tests, for Pupils and Teachers, in General Science. H. A. CUNNINGHAM. *Gen. Sci. Quart.*, **13,** 61–9 (Jan., 1929).—A good test in general science should possess validity, reliability, and objectivity. For the purpose of the discussion, tests are divided as follows: (1) tests to measure the performance of pupils from which performance we are able to infer (*a*) the degree to which the outcomes set up in the typical general science course have been attained, (*b*) the degree of attainment of the outcomes set up in a specific general science course, (*c*) the pupils' ability to employ the various elements of scientific thinking and to throw the necessary safeguards around each step of the process, (*d*) their ability to use successfully the various study skills that are necessary in the successful study of general science; (2) tests to measure the performance of *teachers* from which we may infer the ability of teachers to meet successfully typical problematic situations in teaching of general science. The Ruch-Popenoe, Powers General, Dvorak General, and the Downing Group tests are compared in many important points. J. H. G.

THE METHODS AND PHILOSOPHY OF EDUCATION

The School of Tomorrow. EDITORIAL. *J. Nat. Educ. Assoc.*, **8,** 1–2 (Jan., 1929).—Some of the new trends are: (1) education will be defined as guided growth; (2) the school of tomorrow will start earlier in the life of the child; (3) its guidance will

be longer and will release it more gradually; (4) it will be associated with greater provision for the life-long education of adults; (5) there will be better teachers; (6) it will distinguish between noble art of teaching and routine aspects of school management; (7) objective measurements will be used; (8) mechanical equipment will aid learning; (9) it will work toward broader objectives; (10) there will be a freer atmosphere; (11) it will lay in rich sensory experience the foundation for a vigorous and well-balanced mental life; (12) it will deal with all behavior-problem children up to maximum school age; (13) there will be an elimination of failure; (14) it will not consider its task complete until all children of school age are fitted successfully into the activities of citizenship and vocation. A. E. C.

The Present Chaos in Reorganization. EDITORIAL. *High-Sch. Quart.*, **17,** 50–1 (Jan., 1929).—Dr. Jessen of the Bur. of Educ. has recently made a study of the different ways he found elementary-secondary schools reorganizing in the U. S. He found 28 of which the 9–4, 8–4, and 7–4 plans, almost universal a few years ago, are now being superseded by the 6–3–3; 6–6; 6–2–4; 5–3–3; 6–5; 8–3; 8–4–4; 7–6; 7–4–2 and other plans among twenty-eight. There seems to be a tendency toward the shortening of the elementary-secondary school period. It is no longer a heresy to propose a shortened school period. It can be accomplished in six or seven years. This means a corresponding readjustment in high-school and junior college periods. J. H. G.

One Challenge to the Secondary School. R. M. GUMMERE. *Gen. Mag. & Hist. Chron.*, **31,** 203–8 (Jan., 1929).—This Headmaster compares Westminister School (classical) and Beaufoy Junior Technical School (vocational) with corresponding schools in America. The future of the American secondary school is a real challenge to the educators of our country. The secondary school period of education in the United States is in a frankly bewildered condition. They run the risk of being standardized, superficial, and lacking in cumulative thoroughness. There is no inertia in the search for a solution of the difficulty. Treat the boy of fifteen to eighteen as a human being and not a memorizer of facts; in his fourth year let him pursue some chosen topic as a major; cut down the number of subjects and carry the one in which the pupil shows a real interest at school to the point corresponding with the close of the college freshman year. The craze to "correlate school studies with life" often results in carrying the pupil farther away from life; the point is not so much what we study as how we study it. We need simply to intensify and develop what we already have, and to cast off non-essentials. J. H. G.

Why Public Schools Are Public. R. H. REYBOCK. *Wash. Educ. J.*, **8,** 103–4, (Dec., 1928).—The Puritans recognized the need of education for the well-being of the social and political order which they had inherited. Therefore the colonists gave to America the idea of the public school. It has grown and become a gigantic institution. The mistaken notion of education being a charitable affair for the sake of our children has no foundation in the law. Since Americans are charitable we appeal to them for support of education upon such grounds. From the viewpoint of the law education has always been one way of promoting the general welfare, the perpetuity of the Republic's institutions depend upon it. It is a police power of the state. The crime bill is one which education should reduce. When the public is aroused to see the facts and becomes aware that education is not a local affair, but a state and national affair; and that we suffer nearly as much for the failure of education among our neighbors as they themselves; and that learning, culture, and the things of which civilization is made do not stay where they are produced, but move with those that have them; and that ignorance, undisciplined emotions, and barbarism are brought among us by those who have them, only then shall we have the public's coöperation, and be able to place the best schools where they are needed the most. Educators must bring the public to see the real purpose of education and then with the public's assistance endeavor to construct an educational system which will more nearly justify its *raison d'etre.*
A. E. C.

A New Type of Junior College. M. COATS. *J. Nat. Educ. Assoc.*, **18,** 5–6 (Jan., 1929).—See THIS JOURNAL, **6,** 392 (Feb., 1929). A. E. C.

Coöperative Courses in College. W. H. TIMBIE. *Sch. & Soc.*, **28,** 709–14 (Dec. 8, 1928).—The writer aims to correct false ideas which exist concerning coöperative courses by telling how such courses in electrical engineering are conducted at M. I. T. Results of a recent survey of the positions and salaries of graduates of this course indicate the degree of success with which it is being carried on.

The coöperative plan of education, because of its great flexibility, can readily be adapted to any locality or any institution. K. S. H.

Is the American College Still Needed? N. E. BYERS. *Sch. & Soc.*, **28,** 673–5

(Dec. 1, 1928).—A division of the four-year college course—adding the first 2 years to the high school and making the last 2 years a part of the graduate and professional work of the university would seem to relieve the dangerous situation which now threatens the American college. At the end of a 6-year high-school course an individual would, under such a system, be prepared for life while the task of improving life and adding to the knowledge already acquired would be left to the university. A student would take certain subjects because of their cultural value and not because they were required or with the idea of following them up. K. S. H.

Needed Changes in American Institutions of Higher Learning. H. HOLT. *Gen. Mag. & Hist. Chron.*, **31**, 191–7 (Jan., 1929).—The article opens with Dr. F. L. Patee's definition of a college as "costly land upon which are many costly buildings embowered in distinctive landscape gardening surrounded by luxurious palaces called fraternity houses, and all of it handy to a mammoth million dollar coliseum, the seat of frequent gladitorial games—the whole forming a completely equipped city-or-country-club for thousands of tens of thousands of young men and women." Holt visited 300 institutions of higher learning in the last fifteen years. He finds the chief fault to be the insatiable impulse to expand materially; while nearly every institution pays its professors salaries that could be discharged without difficulty in postage stamps, and permits a ten-dollar boy to attempt to get a thousand-dollar education. Many of these youths develop that most blighting of youthful affections—the inferiority complex. Dean Briggs once satirically suggested that small colleges proclaim the advantages of smallness only to become bigger. Many college presidents whip the professors to research work when they are not at all qualified for it. Every Institution has one, two, or rarely three great teachers. Rollins College limits its student body to 700, and only those professors join the circle who have the nobility of character and the gift of teaching which alone can inspire youth. Rollins Institute has substituted for the lecture recitation system, the so-called "Conference Plan." A recent statement signed by twenty-two college professors declared that the greatest weakness of the modern college is that it has failed to bring inspiration to its students or encouragement to scholarship. J. H. G.

Changing Educational Methods in American Institutions of Higher Learning. W. W. COMFORT. *Gen. Mag. & Hist. Chron.*, **31**, 181–3 (Jan., 1929).—During the last few years there has been a great change in the demand made by the best students upon their college instructors. It used to be that the student "passed" if he recited well on the lesson assigned. The best students settled back into mediocrity. Education is one of the spheres in which the youth has come up against an old-fashioned system and claimed the right to criticize and reform it. Our students are capable of more and better work than they have been called upon to perform. The student is now told what ground he must cover and he is given greater liberty in accomplishing the work before the day of reckoning. This change smacks of British and European universities. A large part of our country is given over to mass production where credits are won on an adding machine. It is idle to assume that all are equally gifted. Sooner rather than later, the brilliant separate themselves from the dull. This is a natural law and must be taken into account. It will be well for some colleges to plan exceptional opportunities for those who may come from the humblest origins. For some time pedagogical effort has been largely expended in trying to make purses out of sow's ears. At last we are devoting some attention to those who bid fair to make the best return on the public investment in education. In doing so we are only following in the steps of the older nations which have long concentrated their efforts on the development of leaders. J. H. G.

Recent Educational Developments in Harvard College. A. C. HANFORD. *Gen. Mag. & Hist. Chron.*, **31**, 183–90 (Jan., 1929).—Reprint from a booklet published by Harvard "Crimson." "In the development of its educational methods and policies during the last twenty years Harvard College has acted on the principle that the college cannot by its own efforts educate the student but can merely subject him to a process by which he may educate himself, and that so far as possible the work of the student should be adjusted to fit his individual needs and aptitudes. As a means of accomplishing these ends, the former requirements and methods have been supplemented during the last decade by the adoption of the general examination and tutorial systems and the newly established reading periods. At the same time an attempt has been made to give more attention to the individual student in his transition from school to college, a plan of athletics for all has been evolved, a greater measure of freedom has been given to the students, and a closer coöperation between the undergraduates and the faculty has been brought about." J. H. G.

Why So Many Students Fail. *Sch. & Soc.*, **28,** 629–30 (Nov. 17, 1928).—Many more vocational schools are needed to take care of the countless individuals who are now attending high schools but who are not fitted to pursue academic courses.
K. S. H.

Visual Education—What Is It? C. ROACH. *Educ. Screen*, **7,** 155 (Dec., 1928).—"Visual education is in reality an idea, the central thought being objective presentation rather than subjective discussion of abstractions."

Some objectives for visual education include: motivation, providing new experiences, creating background atmosphere, and supplementing other sense impressions. "Some have called it a happier way of learning."
B. C. H.

What Is Graduate Work? D. A. ROBERTSON. *Bull. Am. Assoc. Univ. Profs.*, **14,** 592–4 (Dec., 1928).—A graduate school, a member of the Association of American Universities, in 1926–27 showed out of 1842 course registrations by graduate students, 643 listed as graduate courses, 1000 listed as senior courses and 199 were junior courses, or 65% were in senior college courses. In 1901, the Association of American Universities went on record "it is not desirable at present to interpret the phrase 'graduate study.' " Has the passing of a quarter of a century of time with its many instances similar to that just related not made it "desirable at the present to interpret 'graduate study?' "
B. C. H.

THE PHILOSOPHY OF SCIENCE

The Fundamentals of Science. J. H. SIMONS. *Sch. Sci. & Math.*, **28,** 966–74 (Dec., 1928).—Author deplores lack of ability of students taking physics and chemistry to use English language clearly, to use mathematics, and to use and appreciate the use of a logical method of thought. In the belief that this lack handicaps teaching of science, author suggests a coördination course to precede science courses and to require of all freshmen. Purposes, results desired, and general outline of such a course are given.
B. H. B.

The Spirit of Science and a New Book. EDITORIAL. *Silicate P's & Q's*, **9,** 1–2 (Jan., 1929).—"From infancy forward we are engaged in the making of observations, of acquiring facts," . . . the value of these facts and observations "depends upon our ability to understand the relations between the things we have gathered—to form some intelligent notion of the Why? The great body of organized knowledge based upon observation is called science. It differs from speculative thinking inspiring a zeal for collecting more facts and a readiness to set aside old theories in favor of new ones which correlate more observed facts."

The relationships between observed data, this correlation between accumulations of facts in some limited field of science is often best recorded in the form of a book. So considered, the advent of a new book in science is the occasion for expectancy upon the part of all workers in that field. To justify its appearance it should, in essence, be a presentation of new relationships, the setting forth of clarifying generalizations.
B. C. H.

The Place of Physics in the Modern World. J. ZELENY. *Science*, **68,** 629 (Dec. 28, 1928).—Address given Nov. 30, 1928, at the dedication of the new physics laboratory at the University of Minnesota.
G. H. W.

THE TEACHING PROFESSION

The Art of Teaching. A. H. UPHAM. *Sch. & Soc.*, **28,** 769–74 (Dec. 22, 1928).—In his inaugural address, Pres. Upham tells something of the history of and conditions at Miami Univ. and of her 13 presidents who so successfully combined teaching with their administrative duties. Classes at this institution were always small which made for intimate personal contact between faculty and students.

Miami acknowledges the marvelous development which has been made in educational methods and technic but nevertheless has had a system all its own—a system which has been remarkably successful. Perhaps this success has been due to the character and personality of its teachers who have had the ability to impart a desire for culture and a love of learning to those who worked with them.

Miami, one of Ohio's two state universities, has for 25 years maintained a successful teachers' college along with its liberal arts course. Now a new school of business administration is to be added and it is earnestly hoped that the liberal culture of an arts college will be added to business methods and procedure so that a well-balanced course providing a cultured background may result.
K. S. H.

Training College Teachers. C. C. LITTLE. *Bull. Am. Assoc. Univ. Profs.*, **14,** 603–6 (Dec., 1928).—Such training he considers may be grouped as: (1) knowledge of

subject matter; (2) methods of instruction; and (3) nature of the pupil. Of these three he considers the college teacher, as a rule, is most deficient in the third.

A survey reported only forty-four college instructors having a "favorable" attitude toward their students against seventy without that attitude; sixty-two high-school teachers so disposed versus eight without, while the elementary school teachers had twenty-nine "favorable" to two who were not. The implication is that the college teacher has not learned to take an interest in the "nature of his pupils."

Doctor Little sees promise in the present interest shown by college teachers in "ability grouping" of students. If such beginnings can be further developed into an all-around interest in individual differences, a start toward remedying the before-mentioned deficiency will have been made. B. C. H.

The High-School Teacher and Research. R. D. REED. *Neo-Chemto-Ion*, **3**, 18, 20 (Nov., 1928).—See Chemical Digest, THIS JOURNAL, **6**, 564 (Mar., 1929). M. W. G.

MISCELLANEOUS

The Grasselli Medal Award for 1928. *Crucible*, **13**, 4 (Jan., 1929).—The Grasselli Medal for 1928 has been awarded Mr. H. J. Rose, assistant director of research for The Koppers Company, Pittsburgh, Pa., by the Grasselli Medal Committee of the American Section of the Society of Chemical Industry. This signal honor is accorded to Mr. Rose for his paper, "Importance of Coal Preparation in the Manufacture of Gas and Coke," which represents the culmination of several years of scientific research in The Koppers Company Laboratories and as a research fellow at Mellon Institute. Mr. Rose is the first to receive the medal under the new rules, which specify: "The Grasselli Medal may be awarded annually for the thesis offering the most useful suggestions in applied chemistry presented at a meeting of the American Section of the Society of Chemical Industry or any joint meeting of this section with another scientific society. The medal committee is privileged to take under consideration the papers presented during a period of five years preceding the date of the award."

Account includes photo, training, and activities of Mr. Rose. M. W. G.

Edward Mallinckrodt Chemical Laboratory. *Harvard Alumni Bull.*, **31**, 1 (Sept. 27, 1928).—"The new Mallinckrodt laboratory is finished. This laboratory is connected with the smaller Converse Laboratory on Frisbie Place by a covered passage, and these new buildings, together with the T. Jefferson Coolidge and Walcott Gibbs Memorial Laboratories, built in 1913, form an impressive group, homogeneous in style, fully equipped, and admirably adapted to their purpose." S. W. H.

Education Pays Cash. EDITORIAL. *Review of Reviews*, **78**, 554 (Nov., 1928).—Results of survey of business college fraternity Alpha Kappa Psi under direction of Everett W. Lord of incomes of 7396 individuals classified in several groups as to education. The report is obtainable in pamphlet form. G. H. W.

Chemical Engineering Education and Research in Great Britain. W. E. GIBBS. *Chem. & Ind.*, **47**, 1304–7 (Dec. 14, 1928).—Professor Gibbs points out some of the differences between the test tube experiments of the chemist and the ton lot reactions of the chemical engineer. The difficulty of training an engineer in the laboratories of English universities is due largely to a lack of knowledge as to just what a chemical engineer should be. He should be able to visualize complete processes; be familar with plant arrangement, flow sheets, costs, etc. He should be able to select and control skilled and unskilled labor. E. R. W.

The Research Laboratory of Applied Chemistry, M. I. T. H. O. FORREST. *Tech. Eng. News*, **9**, 327, 354 (Jan., 1929).—A history of the organization of this laboratory at the Mass. Inst. of Tech. The two major objectives of this laboratory: "(1) training of men in methods of industrial research and (2) conducting general research of value to the public as a whole;" and some of its accomplishments are briefly set forth.

This laboratory is self-supporting except for space, heat, power, and other facilities. Of the income from contract research approximately 65% is used in that field and the remaining 35% is expended for general service research. Although the confidential nature of contract work cannot in most cases be stated until completed, a statement of some problems already solved and others being studied show the scope and great importance of the work that may be done in an industrial research laboratory of applied chemistry. However, perhaps of even greater significance is the man power sent out from such a department as shown by illustrations in this article. L. W. M.

The Formation of the Élite. H. M. LE CHATELIER. *Sci. Mo.*, 212–24, Sept., **1928.**—See Chemical Digest, THIS JOURNAL, **6**, 565 (Mar., 1929). M. W. G.

Local Activities and Opportunities

Through these columns, the JOURNAL desires to render a two-fold service.

1. Local Activities. Keeping its readers in touch with the varied interests of institutions, A. C. S. sections, teachers' asssociations, and other organizations throughout the country. Items of general interest would include: (1) notices of local scholarships or fellowships; (2) notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.; (3) accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations (where original or unusual features are included it is desirable that they be described in some detail); (4) news notes concerning persons of sufficient prominence in their respective fields to make their movements of general interest; (5) promotions within, or changes of, personnel of a department; (6) announcements of new or unusual courses in chemical education or special fields of chemistry; (7) notes on new chemistry buildings or laboratories, stressing the unique features.

2. Opportunities. Providing an exchange column for positions. That is: (1) any teacher who is a subscriber to the JOURNAL, desiring to change his position, may advertise once a year without charge (correspondence will be handled through the editorial office, if desired); (2) any notices of vacancies, in which chemistry teachers and chemists will be interested, will also be published.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It would be desirable to have some person connected with each organization and institution appointed to report regularly.

Suitable material sent to the editorial office before the 20th of each month will be published in the following month's JOURNAL. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the above suggestions are followed, however, the necessity for such action will be largely obviated.

Situation Wanted as ASSISTANT IN FOOD ANALYSIS OR IN PHYSIOLOGICAL OR BIOLOGICAL RESEARCH by woman, college graduate. Can accept position in Eastern States only. Address 32 Vassar Street, Worcester, Mass.

Western Reserve University. The Jeavons Graduate Fellowship in Chemistry at Western Reserve University of Cleveland, for pure science research in inorganic chemistry, provided by the J. H. R. Products Co., has recently been awarded to Mr. Roland Ward, a graduate of Paisley Technical College, Paisley, Scotland, and the University of London. Mr. Ward has had a broad fundamental training and has had several years of experience in industrial chemistry both abroad and in this country.

The Jeavons Fellowship carries a stipend of $1200 per year with exemption from tuition and laboratory fees. No teaching is required, the fellow devoting his entire time to graduate study leading to the Doctor of Philosophy degree. The appointment is made for one and one-half years, the present one ending July, 1930.

GRADUATE FELLOWSHIPS FOR 1928–1929

The Cushman Graduate Fellowship. Established 1924 by Mr. H. D. Cushman, President of the Ferro Enamelling Co., for fundamental research in reactions at high temperatures. The present studies are concerned with those reactions evolving gases. The stipend for this fellowship is $900 and exemption from tuition and laboratory fees, or a total value of approximately $1200. Appointment for one year, but the fellow is eligible to reappointment at an increase in stipend of $300 providing his work is satisfactory.

The Ohio Chemical Graduate Fellowships. Two fellowships established 1927 by Mr. J. G. Sholes, President, The Ohio Chemical and Mfg. Co., for fundamental research in gases, particularly in the chemistry of anesthetic gases. The stipends for these fellowships are $900 a year and exemption from tuition and laboratory fees, or a total value of approximately $1200, and the fellow is eligible for reappointment providing his work is satisfactory.

In the above fellowships, no teaching is required and the Fellow's entire time must be devoted to graduate study, but the Fellow will be permitted a vacation of one month during August. Fellows to be appointed now will be expected to begin work June 24, 1929, for one year. In addition to his research which will be the

basis for his thesis, the Fellow will pursue advanced courses toward the Doctor of Philosophy degree.

These fellowships are open only to graduates of accredited colleges, preferably with some graduate training. Applicants should have thorough foundation in chemistry and physics, and a reading knowledge of French and German. Experience in the manipulation of gases and in the simpler operations of glass-blowing is desirable. Letters of application must be accompanied by a recent photograph of the applicant, by an official transcript of the applicant's undergraduate and graduate record, and by direct sealed letters from qualified persons indicating his character, health, ability, and accomplishments.

Applications should be made before April 1st, to Dean of the Graduate School, Western Reserve University, Cleveland, Ohio.

University of Pittsburgh. During the week of February 4th, Professor Alexander Silverman, Head of the Department of Chemistry of the University of Pittsburgh, attended the annual convention of the American Ceramic Society in Chicago and delivered the opening address of the Glass Division, Tuesday, February 5th, on "Modern Glass Manufacture in Europe and Glass Collections in European Museums." He showed four reels of motion pictures that were taken during his three month tour of Europe last summer, which included matters of ceramic interest in France, Italy, Czechoslovakia, Germany, Holland, Belgium, England, and Scotland. He reported as Chairman of the Education Committee on glass education in Europe. At this meeting plans were discussed for the tour and reception of the British ceramists who will visit the United States in the spring.

Northwestern University. A new departure for the chemistry department of Northwestern University is the organization of a non-credit seminar among the more mature students and the younger instructors. Its purpose is to provide a medium for discussion of the more neglected phases of physical organic chemistry. The general theme will be the relation of physical properties to chemical constitution. Among the topics on the tentative program are: magnetic permeability, magnetic rotation, size and shape of molecules, dielectric constants, electrical absorption and liquid gratings. The non-credit feature is expected to eliminate the "dead wood" and to insure spontaneous debate and criticism.

University of Nevada. At a recent meeting of the chemistry staff with a number of the advanced students in the department, Professor G. W. Sears, head of the department of chemistry and Consulting Chemist, U. S. Bureau of Mines, reviewed his work on the fusion of rare metal ores. The latest portion of this work was published in the *J. Am. Chem. Soc.*, in January, 1929, as the third paper, entitled, "Determination of Tantalum and Columbium."

The chemists of Reno and vicinity have arranged with the Sacramento Section of the American Chemical Society that the Section will be entertained in Reno for the September meeting, while the Reno chemists will be the guests of the Section in Sacramento for the October meeting of this year.

Detailed plans are being drawn up for a new science building, which has been donated to the University by Mr. Clarence Mackay, who has already built and endowed the Mackay School of Mines of the University of Nevada. The new structure will house the departments of chemistry, physics, and mathematics and is to be called the Mackay Science Building. Construction will begin this spring and occupancy should be possible some time during the summer of 1930.

Mr. S. Allan Lough, of the department of chemistry of the University of Nevada, has been promoted to the rank of assistant professor.

The College of the City of New York. A science survey course was started last term and included the general topics of astronomy, geology, and physics. Enrolment was about six hundred. That course is being repeated this term, and in addition, the second half year's work has begun with about the same number of students enrolled, which includes the branches of chemistry and biology. The chemistry lectures (eight in all) are given by Professor Benjamin Harrow, and twice that number of recitations are held by members of the staffs of chemistry and biology. The lectures in biology will be given by Professor Melander of that department.

Mr. Bernard A. Starrs has resigned from the staff of the department of chemistry.

The following men have been appointed Fellows in the department of chemistry: Saul S. Hauben, Casimiro Liotta, Julius Wunsch.

Columbia University. Dr. H. Louise Campbell spoke at a joint meeting of the New York City Dietitians' Association and the Greater New York-Southeastern District Home Economics Association on Monday, February 11th. Her subject was "The Relation of Diet to Health and Vitality."

Professor V. K. La Mer addressed the Philadelphia Section, A. C. S., on February 21st. The subject of his talk was "Neutral Salt Action."

Professor A. W. Thomas lectured on the "Fundamental Chemistry of Colloids" before a joint meeting of the Porter Scientific Society of Franklin and Marshall College, and the chemists of the Armstrong Cork Company in Lancaster, Pa., on February 14th.

Rutgers University. Rutgers University scored the highest ranking in a chemistry test given in twenty-eight of the land grant colleges in the United States, according to a report received by Dr. Peter A. van der Meulen, professor of general and physical chemistry at Rutgers. Announcement of the results of the nation-wide test is made in the annual report of the committee of instruction of the Association of Land Grant Colleges, which conducted the examination as a method of measuring teaching efficiency.

The test was given at the close of the last school year to members of the freshman class in chemistry of the twenty-eight colleges. The median or middle score of the 250 students taking the test from Rutgers was 87, while the median score of the second highest institution was 80.50. Other colleges ranked from 78.4 to 37.25.

One objective of the examination was to test the teaching efficiency of the instructors by obtaining the average median grade of those students who had had high-school chemistry, and those who had studied chemistry in college for the first time. It was found that the median grade of the 182 students at Rutgers who had had high-school chemistry was 93, and that of the 68 who had not had such previous training was 74.

The scope and content of the text used were developed as a result of careful analysis of the various textbooks used in college courses in general chemistry. The test in each instance was given under standard conditions.

Dr. Ralph G. Wright is head of the Rutgers chemistry department.

Among the twenty-eight colleges taking the examination were Arizona, Cornell, Georgia, Kansas, Montana, Nebraska, New Hampshire, Penn State, and Virginia.

Cincinnati Section, A. C. S. The 304th Meeting of the Cincinnati Section of the American Chemical Society was held in the Chemical Auditorium of the University of Cincinnati on February 13, 1929, at 8.00 P.M.

Professor Wilber Stout of the Department of Geology at Ohio State University addressed the Section on "The Ceramic Industry of Ohio." Originally a chemist, Professor Stout was attracted to a study of the stratigraphy of the coal deposits of

Ohio and an investigation of the geology of Ohio fire clays. His reputation in this field has become national. His appointment as Ohio State Geologist, succeeding Dr. Bownocker, recently deceased, is an assurance of his continued activity in this field.

The 305th Meeting was preceded by an informal dinner served in the Women's Building of the University of Cincinnati at 6.30 P.M., Wednesday, March 13, 1929.

The regular meeting opened at 8.00 P.M. in the Auditorium of the Chemistry Building. The speaker was Austin M. Patterson, professor of chemistry at Antioch College, whose subject was "International Chemistry."

Dr. Patterson is a former editor of *Chemical Abstracts*, a Councilor of the International Union of Pure and Applied Chemistry, a member of the International Committee on Organic Nomenclature and Chairman of the American Committee on the same subject. His extensive intercourse with foreign chemists and his wide acquaintance with chemical literature have given Dr. Patterson a unique ability to deal with such a subject.

Lexington Section, A. C. S. The 132nd regular meeting of the Lexington Section of the American Chemical Society was held in Kastle Hall, University of Kentucky, at 4.00 P.M., Tuesday, February 12, 1929. Dr. G. Davis Buckner spoke on the topic "The Hydrogen-Ion Concentration of the Reproductive Organs of the White Leghorn Chicken." Dr. Buckner gave us a preliminary report on important and significant results obtained from recent researches in his chosen field of biochemistry.

The 133rd meeting was held in Kastle Hall, University of Kentucky, on Tuesday, March 12, at 4.00 P.M. Dr. A. S. Richardson of the Chemical Division of the Procter and Gamble Company spoke on the topic "The Hydrogenation of Vegetable Oils."

Ninth Annual Educational Conference at Ohio State University. The Ninth Annual Educational Conference at Ohio State University, Columbus, will be held on April 4, 5, 6, 1929. More than twenty out-of-state speakers have been engaged to address the general and sectional meetings. The speakers are well known in their particular fields, and their addresses will cover a wide range of educational interests.

Three new sections—Adult Education, Attendance Supervisors, and Higher Education—have been added to the Conference Program this year. The Adult Education Section will be directed by Mrs. Jessie Allen Charters, an expert in adult-parental education, who is a regular member of the Ohio State University faculty. A. O. Heck, professor of school administration in the College of Education, has charge of the sectional program for attendance supervisors, school nurses, and visiting teachers. The new director of the University's Bureau of Educational Research, W. W. Charters, will preside at the meetings of the Higher Education Section. Mr. Charters was recently made editor-in-chief of the *Journal of Higher Education* which will be issued for the first time next September by the Ohio State University Press.

Chemistry's Next Job. Dr. Charles H. Herty says the ultimate mission of chemistry is good health. A writer in *Discovery*, published in London, says that chemistry's next war will be a war to kill germs.

Putting one and one together, we get a picture of another great job for chemistry!—*Business Chemistry*

Recent Books

The Theory and Technique of Quantitative Analysis. MARIE FARNSWORTH, Ph.D., Instructor in Chemistry, Washington Square College, New York University. First edition. John Wiley & Sons, Inc., New York City, 1928. vii + 154 pp. 15 × 23 cm. $2.50.

The object of the book is to emphasize the theory and technic of Quantitative Analysis and may be summarized in a statement of the foreword: "The true analyst must analyze his method before he can analyze his sample." In the main the foregoing object has been fulfilled.

Acknowledgment is made to "the extensive use of material originally used by Dean Gerald Wendt of the Pennsylvania State College in his courses at the University of Chicago and Pennsylvania State College." The foreword is written by Dr. Wendt in a brilliant manner.

The following chapters make the contents of the book: The Balance, Precision of Measurements, Laboratory Ware, Reagents and Their Purification, Preparing the Sample for Analysis, Precipitation: Factors Bearing on the Purity of the Precipitate, Filtration, Water of Crystallization: Drying and Drying Agents, Volumetric Analysis, Acidimetry and Alkalimetry, Preparation of Standard Acid and Alkali Solutions, Precipitimetry, Oxidation and Reduction, Electrolytic Processes, and Electrometric Titrations.

Strange as it may seem, the names of neither Dr. Farnsworth nor Dr. Wendt appear in the index. This may be due to modesty.

It is very necessary on p. 49 to give experimental data to support the conclusion arrived at. A statement that the author is "riding on the band wagon" is not always convincing, especially when the experimental facts favor the reverse order of precipitation of barium sulfate.

The chapter on Precision of Measurements should be enlarged in order to cover the field. The terms accuracy and precision should be defined and then used correctly throughout the book. In additions and subtractions one must pay attention to the number of decimal places and not to significant figures (p. 27). A rule for rejection of superfluous figures should be given.

Normal and molar solutions are defined on p. 97, but the terms are used in earlier chapters. Equations, such as $E = \epsilon_0 - 0.0591/5 \log [MnO^-_4] [H^+]^8/[Mn^{++}]$ are confusing and should be written

$$E = \epsilon_0 - \frac{0.0591}{5} \log \frac{[MnO_4^-] [H^+]^8}{[Mn^{++}]}$$

The products of reduction of permanganate ion in varying concentrations of hydrogen ion (p. 114) should be corrected. The impression made by the equations on the bottom of p. 119 and on the top of p. 120 is erroneous. Sodium and sulfate ions are not discharged on electrolysis of sodium chloride and sodium sulfate solutions, respectively. The chapter on neutralization should precede the chapter on precipitation. An atomic weight table should be given.

Due credit should be given to Goode for his valuable contributions to continuous and automatic electrometric apparatus. Indicators like methyl orange or phenolphthalein (p. 90) cannot be used in precise work without due corrections in titrations involving strong acids and strong bases. There are no problems and detailed laboratory procedures are not given.

The book is clearly written. There are only a few typographical errors such as:

$\frac{[H^+]\,[OH^-]}{[H_2]}$ = K (p. 76), $BaSO_2$ (p. 47).

STEPHEN POPOFF

STATE UNIVERSITY OF IOWA
AMES, IOWA

Chemistry in Medicine. A coöperative treatise intended to give examples of progress made in medicine with the aid of chemistry. Edited by JULIUS STIEGLITZ, Professor of Chemistry, University of Chicago, and the following advisory editors: Anton J. Carlson, Professor of Physiology, University of Chicago; Reid Hunt, Professor of Pharmacology, Harvard Medical School; Frank R. Lillie, Professor of Zoölogy, University of Chicago; Lafayette B. Mendel, Professor of Physiological Chemistry, Yale University; H. Gideon Wells, Professor of Pathology, University of Chicago. The Chemical Foundation, Inc., 85 Beaver St., New York City. 25 illustrations. xxi + 757 pp. 13 × 17 cm. $2.00.

The impetus which led to the preparation of this book had its origin some years ago in the tragic loss of a beloved child, Patricia, by Mr. and Mrs. Francis P. Garvan of New York City and the frontispiece is a reproduction of a painting of Patricia. No one can look at the picture of this charming little lady without sympathizing with Mr. and Mrs. Garvan and understanding why they wish to do something in her memory. The title page of the book bears this inscription: "This book is dedicated to the welfare of your children and your children's children by its authors and publishers."

One needs only to read the names of the editor, the advisory editors, and the authors to be assured of the outstanding value of this book. The following quotations taken from the Foreword tell us something of what the Chemical Foundation had in mind in its publication. "This book is intended to present to the public as well as to the practitioners of medicine the great possibilities for advance in medical science through further intensive coöperation between chemistry and medicine. . . . . Chemistry is the fundamental science of the transformation of matter, and our life, from our inception to our return to dust, in every breath we draw and in every moment we live, is indissolubly connected with most complex transformations of matter. These take place in our blood, in our tissues and our organs. Admittedly the life sciences still know far too little about these complex but fundamental chemical phenomena to make possible that clear insight into and positive control of factors of life and health, which must be the basis of a science of medicine. . . . .In the chapters that follow, the story will be told of some of the most important successes, already assured, in the combating of disease and alleviation of suffering through this alliance of sciences. . . . . The authors include eminent physicians, pathologists, pharmacologists, physiologists, and bacteriologists as well as chemists. . . . .Each story will be told by a specialist in his field and as far as possible in non-technical language that any layman can follow."

Here indeed is a rare treat for every intelligent person. Think of what it means to be able to read such articles as the following merely picked at random from the book: "The Significance of Chemistry and of Its Methods of Attack on Fundamental Problems" by Julius Stieglitz; "The Story of the Discovery of the Vitamins" by E. V. McCollum and Nina Simonds; "The Advance Against Pellagra" by the late Joseph Goldberger; "The Hormones of the Suprarenal Glands" by John J. Abel and E. M. K. Geiling; "The Story of Thyroxine" by Edward C. Kendall; "Insulin to the Rescue of the Diabetic" by J. J. R. MacLeod; "Safe-Guarding the Water We Drink" by John F. Norton; "General Anesthesia" by Arno B. Luckhardt; "Chemistry and High Blood Pressure" by Ralph H. Major; "The Germ Theory of Disease" by Edwin O. Jordan; "The Hope of the Leper" by Roger Adams; "Iodine in the Prevention and Treatment of Goiter" by David Ma-

rine; "The Battle against Tuberculosis" by Esmond R. Long.

The book contains altogether thirty-nine articles and there is not a page of dry or unimportant reading in all of them. The reader derives special satisfaction from the fact that the story is told in each case by an authority upon the subject. So much is printed nowadays upon such a subject as, for example, "insulin," that one often wonders if what he reads really represents the facts as they are known today; but in this book one can read with perfect assurance on this point. The reviewer would like to quote from many of the articles but this is not possible and he can only assure any one who has not read the book that a treat is in store for him.

Mechanically, the book is a fine specimen of book-making with flexible back and thin paper. It must be added that all of the editors as well as all of the authors of the chapters in the book contributed their services gratuitously. Moreover, the price at which the book is sold is not more than sufficient to pay the cost of publication.

WILLIAM McPHERSON
THE OHIO STATE UNIVERSITY
COLUMBUS, OHIO

Laboratory Manual, arranged to accompany the third edition of "A Course in General Chemistry." WM. MCPHERSON, WM. EDWARD HENDERSON, AND WM. LLOYD EVANS, Professors of Chemistry, Ohio State University. Ginn and Company, Boston, Mass., 1928. vii + 165 pp. 79 figs. $1.20.

This excellent manual—one of the most attractive and carefully prepared of those now available in elementary general chemistry—is the result of many years of experience with large classes at the Ohio State University. The 95 exercises cover the usual elementary principles, with experiments upon the non-metallic and metallic elements. Some new quantitative experiments are introduced, which have apparently been very carefully worked out, such as that on the molecular formula of steam.

The arrangement of the material under each exercise heading is attractive. The purpose and general character of each experiment is clearly stated in the beginning. Drawings are given in sufficient number and detail to be very helpful. We are glad to note that working directions are not too frequently interrupted by questions. By numbering the questions that do appear, the correction of student notebooks is simplified. The reviewer noticed no misprints, but may suggest that Exercise 20 is rather an illustration than a proof of the law of multiple proportions. An appendix listing equipment and chemicals, with directions for first aid, should prove very useful.

H. G. DEMING
ARTHUR D. LITTLE, INC.
CAMBRIDGE, MASS.

The Collected Works of J. Willard Gibbs. Longmans, Green and Co., New York City, 1928. Vol. I. xxviii + 438 pp. Vol. II. xviii + 207 pp.: vi + 284 pp. 23 × 15 cm. $6.00 set.

This first complete edition of the works of Willard Gibbs will be warmly welcomed by chemists and physicists both as a fitting memorial to the author and as a most helpful addition to current scientific literature. It is obviously proper that there should be a complete edition of the works of the man that few would hesitate to call America's greatest scientist; but it is startling to remark that the practical usefulness of such a collection of his papers is greater at present than it has ever been before. Today the increasing use of statistical methods in theoretical chemistry, and of thermodynamics in applied chemistry is turning chemical thought more than ever before toward those fields that were so clearly mapped in the course of their first exploration by Gibbs. Those who are carrying on his work cannot find any more inspirational or practical guide than his original papers.

Gibbs' treatise on statistical mechanics, and the first collection of his works which included everything except this treatise,

have both been out of print for about ten years. The plates of the present edition have been made by a photographic process from those two earlier books, giving a beautifully clear print with, of course, absolute freedom from typographical error. The size of the page has been reduced from $6^1/_4'' \times 9^3/_4''$ to $5^3/_4'' \times 9''$ and the weight of the books appreciably lessened.

There have been no changes made in the subject matter, and little in its arrangement. Thus the first volume, as in the previous collection, contains the papers on thermodynamics, including the monograph "On the Equilibrium of Heterogeneous Substances" in which the phase rule is developed. As part one of the second volume we have the treatise on statistical mechanics and as part two the papers on dynamics, vector analysis, and light just as they appeared in the first edition.

DONALD H. ANDREWS
JOHNS HOPKINS UNIVERSITY
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Introduction to Qualitative Chemical Analysis. D. P. SMITH, Associate Professor of Chemistry, Princeton University, and H. K. MILLER, Instructor of Physiological Chemistry, School of Medicine, University of Pennsylvania. First edition. The McGraw-Hill Book Co., New York City, 1928. xii × 275 pp. 31 figures. 14 × 20 cm. $2.25.

The authors have attempted to present two distinct courses of instruction in qualitative analysis and to offer sufficient material in the form of laboratory procedures and theoretical discussion to cover thoroughly either of these courses. The first is so arranged that the student is constantly engaged in making analyses, at the beginning with simple alloys and later with more complex materials. In this presentation great stress is placed upon preliminary examination of the solid material, the preparation of its solution, and particularly upon blow-pipe and other dry tests. The laboratory time for this course is estimated to be about 100 hours, or about 80 hours if the course is abridged as indicated in the outline. The second course of instruction is of more conventional arrangement in which the unknowns are mostly in solution form and preliminary tests are greatly subordinated.

The first course of instruction will doubtless offer greater appeal to the student, but it too often happens that students look upon dry reactions as gifts from Heaven designed expressly to rescue them from the evils of precipitation methods and, with this in mind, proceed to spend twice the time on a simple unknown that would be required by starting almost at once upon the systematic solution procedures. Nevertheless, some knowledge of blow-pipe work and other preliminary tests is desirable, and the excellence of the arrangement of the subject material in this book lies in the fact that the two methods of instruction can easily be combined in proportions and quantities to suit almost any purpose.

The systematic scheme for the analysis of the cations is excellent and has apparently been carefully worked out, although the authors admit that some of the procedures have been given with the idea of teaching chemical principles rather than of offering the best tests available. In many cases auxiliary tests are given which serve to increase the student's knowledge of the characteristic reactions of the elements. The more recent tests, such as the aluminon test for aluminum and Suitsu and Okuma's test for magnesium, are included.

For the acidic constituents, the authors rely almost entirely upon preliminary indications, group tests, and characteristic reactions of the individual ions. There is little or no attempt at systematic separation of the anions.

All the directions for the systematic procedures are written in tabular form to which are appended copious explanatory notes. Fuller theoretical explanations are given in Part II of the book which serves at the same time as collateral reading

matter and as a basis for classroom instruction. Here, again, the instructor can include or omit whatever sections he desires. Many instructors will not care to include in a course in qualitative analysis such topics as the structure of the atom, radioactivity, and Werner's coördination theory. Incidentally, the method of balancing equations as given on page 206, although perfectly logical, is cumbersome, for the application of change of valence can be made and clearly understood without the necessity of treating chemical equations like the simultaneous equations of algebra.

Altogether, this book is thoroughly up-to-date, attractive in appearance, broad in its scope, and so flexible in its arrangement that it should satisfy the requirements in almost any method of presentation. It is especially recommended to those who wish to present a course which not only teaches the fundamentals of qualitative analysis but at the same time greatly broadens the student's knowledge of chemical principles.

STEPHEN G. SIMPSON

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

Qualitative Analysis for Students of Pharmacy and Medicine. CHARLES B. JORDAN, Ph.C., M.S., Dean of the School of Pharmacy and Professor of Pharmaceutical Chemistry, Purdue University, Lafayette, Indiana. McGraw-Hill Book Company, Inc., New York City, 1928. First edition. viii + 169 pp. 8 tables and 1 figure. 14 × 20.4 cm. $2.50.

The purpose of the author in writing this book, as stated in the preface, has been to prepare a book which would be modern in theory and which at the same time would be capable of being applied in pharmacy and medicine.

The introduction makes up the first twenty-seven pages of the text and in these twenty-seven pages such topics as solutions, colloidal suspensions, washing of precipitates, degree of ionization, chemical equilibrium, ionic equilibrium, law of mass action, ionization constant, common ion effect, solubility product, fractional precipitation, hydrolysis, electron theory and oxidation and reduction are discussed.

In the remainder of the text, laboratory directions are given for cation and anion analysis. The cations have been divided into the usual groups and preceding each laboratory procedure there occurs a discussion of the group which includes many extra tests in addition to the one listed in the regular scheme for analysis. Chemical reactions are given for many of these tests. Also, here and there in these discussions occur additional theoretical discussions similar to those found in the introduction but having special application at the place at which they are mentioned. Occasionally also tests having special application to pharmacy and medicine are pointed out in these preliminary discussions. The laboratory procedures are followed by lists of review questions in the case of each of the cation groups. At the end of the text occur the usual solubility table and list of reagents.

In the writer's opinion, Dr. Jordan may be said to have accomplished both of his purposes mentioned above. The book is clearly the result of very careful, painstaking work. The introduction is perhaps the outstanding feature. Where other prominent chemists have failed, Dr. Jordan has succeeded in discussing difficult topics in a way that students will be able to understand with a reasonable amount of application.

The laboratory procedures are for the most part clearly written and should be easily followed, and in most cases will give excellent results. The amyl alcohol-ether test for cobalt apparently is more satisfactory than the old KNO_2 test used by the author. No use is made of the spectroscope in groups four or five, although flame tests are described. The procedures are not accompanied by direct references at points at which difficulties are especially likely to be encountered, although they are

frequently accompanied by a discussion of possible difficulties.

On the whole, the book is excellent and should serve students of qualitative analysis well—much better than many of the older books now available.

LYMAN J. WOOD

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ST. LOUIS, MISSOURI

Volumetric Analysis. Volume I. Theoretical Principles. I. M. KOLTHOFF, Ph.D., Professor of Analytical Chemistry of the University of Minnesota, in collaboration with Dr. Ing. H. Menzel, Dresden, Germany. Translation by N. HOWELL FURMAN, Ph.D., Associate Professor of Analytical Chemistry, Princeton University. First edition. John Wiley and Sons, Inc., New York City, 1928. xvii + 289 pp. Figures 20. 15 × 23 cm. $3.00.

There has been a definite need for a book giving a modern treatment of the theory of volumetric analysis and Dr. Kolthoff has made a laudable contribution to this subject. The author realizes the difficulty of trying to bring together diverse analytical processes under one theory and remarks in italics, on page 115, *yet one should never fail to test the theoretical deductions experimentally, and should not be content merely with the result of the computation.* It is in this spirit that the author develops the theory.

The first three chapters deal with the principles of neutralization, precipitation, complex formation, and oxidation-reduction reactions. As is to be expected, the development is more mathematical and more detailed than that given in the usual laboratory text. Numerous titration graphs are also given. The next two chapters deal with indicators and titration error. Two chapters, showing the relations of speed of reaction, catalysis, induced reactions, absorption and related phenomena to some volumetric processes, present much material not found in the conventional "quantitative" text. A chapter on volumetric organic methods gives a summary of some organic titrations. Two chapters dealing with the stability of solutions and the determination of equivalence-point complete the book. Of the various tables in the Appendix, Table III, giving the solubility product of about seventy salts, deserves especial mention.

As a text the book might prove a bit difficult for second-year chemistry students meeting volumetric analysis for the first time. It will prove of value to students who have a knowledge of inorganic and elementary physical chemistry. The book should be a source of inspiration to research workers and teachers, for Dr. Kolthoff clearly points out the limitations of the theories and data and shows the directions subsequent researches must take.

The book is well set up and is remarkably free from errors. Line 22, page 83, which should read, "The iodine solution is oxidized to iodine—," was the only one noted.

The majority of the references is to the German literature, but this is the sole evidence one has that one is reading a translation. No higher tribute can be paid Dr. Furman.

L. C. CADY

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MOSCOW, IDAHO

Organic Laboratory Methods. LASSAR-COHN, translated by RALPH E. OESPER, Associate Professor of Analytical Chemistry, University of Cincinnati. Edited by ROGER ADAMS, Director of Chemistry Laboratory, University of Illinois. The Williams and Wilkins Co., Baltimore, Md., 1928. xi + 469 pp. 186 figures. $6.50.

This book is number two of The World Wide Chemical Series, edited by E. Emmet Reid. The fifth edition of Lassar-Cohn's work appeared in the original German in two volumes and was published in 1922. Oesper has translated the first of the two volumes which deals with the general operations of laboratory technic. The book should be welcomed by

organic chemists as there is a lack of works in English dealing with this field.

The various operations of the organic laboratory such as distillation, crystallization, sublimation, extraction, filtration, melting- and boiling-point determination, and the analysis of materials for nitrogen, the halogens, and sulfur are discussed. Strangely, a discussion of the determination of carbon and hydrogen is not included. The work does not claim to be complete; it does, however, discuss the difficulties that have been encountered by various investigators, and shows how they have been overcome. The free use of original references is very helpful, and makes it possible for the reader to obtain readily more information than can be included in a work of this size. The abundance of footnotes by the editors is very helpful in correlating German with American practice; furthermore, many methods different from those of the text are suggested. The book is not a text for beginners, but in it the advanced student should find a wealth of interesting and helpful material, and many valuable references.

The translator has done his work admirably; the book is remarkably free from typographical errors, and is very readable. The print is good, but the paper only of fair quality. It is to be regretted that the binding is not better; the reviewer would class it as poor.

Certainly Lassar-Cohn's book, either the original German or this excellent translation, should be found in every collection of works dealing with organic chemistry.

NATHAN L. DRAKE

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

Inorganic Chemical Technology. W. L. BADGER, Professor, and E. M. BAKER, Asst. Professor, Chemical Engineering Department, University of Michigan. First edition. McGraw-Hill Book Company, Inc., New York City, 1928. viii + 228 pp. 14 × 22 cm. $2.50.

This book offered as a text for a course in the technology of the so-called heavy chemical industries, is written primarily from the viewpoint of the chemical engineer. It describes the manufacture of refining of common salt, sulfuric acid, nitric acid (including the fixation of nitrogen in general), the minor acids and soda and caustic, together with a number of miscellaneous products, all discussed on the basis of the latest American practice.

It is refreshing, indeed, to find a new book on chemical manufacturing methods, that is, neither a rambling treatise on everything chemical under the sun, "without form and void" nor yet a sketchy encyclopedia of doubtful up-to-dateness. Messrs. Badger and Baker have concentrated on a limited field and have produced a work that is not only intelligible to the novice but one that convinces the more experienced reader of its soundness and authenticity. Some of the processes discussed have not been previously described in the literature, while ample collateral reference to the others is made through a well-selected list of journal articles that, in the main, goes back less than a decade. Of special pedagogical value are the graphic flow sheets and the lists of practical problems included in each of the major chapters.

In their treatment of the equilibrium of gas reactions the authors have mentioned the van't Hoff equations, but have left much to be supplied by the instructor. In writing a book of this kind such a policy is doubtless justifiable.

The reviewer believes that the adoption of this book will solve, in part, the problems of the instructor in chemical technology who has trouble in finding a suitable text, and he has faith enough in his own judgment to follow it himself.

In physical makeup the volume conforms to the high standards of McGraw-Hill's "Chemical Engineering Series" to which it belongs.

H. L. OLIN

STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA

A Selected Annotated Bibliography Dealing with Examinations and School

Marks. *Bureau of Educational Research*, No. 43. C. W. ODELL, Assistant Director. University of Illinois, Urbana, Illinois. Jan. 15, 1929. 42 pp. 23 × 15 cm. $0.50.

This bibliography is divided into five part as follows: I. General; II. Traditional Examinations; III. New-Type Tests; IV. School Marks; V. Prevention of Cheating.

Department of Chemistry and Chemical Engineering, 1903–1928. *A Commemorative Bulletin*, University of Washington, Seattle, Washington, 1928. 91 pp. 23 × 15 cm.

Contains a report of twenty-five years of chemistry in the University of Washington, publications of the department, courses of study, and faculty and alumni.

Annual Report of the Commissioner of Education, for Year Ended June 30, 1928. *Department of the Interior.* JNO. J. TIGERT, Commissioner. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C., 1928. 42 pp. 14.5 × 23 cm. Paper, $0.05.

Requirements for High-School Graduation. *Department of the Interior*, No. 21. CARL A. JESSEN, Specialist in Secondary Education. U. S. Government Printing Office, Washington, D. C., 1928. 24 pp. 14.5 × 23 cm. $0.05.

Major Trends of Education in Other Countries. *Department of the Interior*, No. 13. JAMES F. ABEL, Associate Specialist in Foreign Education. U. S. Government Printing Office, Washington, D. C., 1928. 48 pp. 14.5 × 23 cm. $0.10.

Land-Grant Colleges and Universities, for Year Ended June 30, 1927. *Department of the Interior*, No. 14. WALTER J. GREENLEAF, Associate Specialist in Higher Education. U. S. Government Printing Office, Washington, D. C., 1928. 77 pp. 14.5 × 23 cm. $0.15.

Private and Endowed Schools Offering Trade and Industrial Courses. *Department of the Interior*, No. 18. MARIS M. PROFFITT, Specialist in Industrial Education. U. S. Government Printing Office, Washington, D. C., 1928. 50 pp. 14.5 × 23 cm. $0.10.

Bibliography of Research Studies in Education, 1926–1927. *Department of the Interior*, No. 22. Prepared in the Library Division, Bureau of Education, John D. Wolcott, Chief. U. S. Government Printing Office, Washington, D. C. 1929. 162 pp. 14.5 × 23 cm. $0.25.

BOOKS RECEIVED—LIBRARY OF CONGRESS, DECEMBER 15, 1928, TO FEBRUARY 15, 1929

Bolton, Edward Richards, Oils, fats, and fatty foods, their practical examination; a handbook for the use of analytical and technical chemists and manufacturers. 2nd ed. Philadelphia, P. Blakiston's Son & Co., 1928. xvi, 416 pp., illus., xii pl., diagrs. 25 1/2 cm.

Bueb, J., Stickstoffwirtschaft; rückblick und ausblick. Berlin, Stickstoff-Syndikat, 1928. 47 pp., col. diagrs. 22 cm.

Caven, Robert Martin, The foundations of chemical theory; the elements of physical and general chemistry. 2nd ed. London, Blackie and Son, Ltd., 1926. xi, 319 pp., illus., diagrs. 22 1/2 cm.

Edson, Lucia Eola, A physico-chemical study of pectin. Poughkeepsie, N. Y., Lansing-Broas Printing Co., Inc., 1928. 29 pp., diagrs. 23 cm. Thesis (PH.D.)—Columbia University, 1928.

Gildemeister, Eduard, Die ätherischen öle. Leipzig, Schimmel & Co., 1928. v., illus., double maps, tables (in pocket), diagr. 23 1/8 cm.

Gilmore, Bernard Harold, Determinations of the average cross-sectional areas of molecules in the terpene and camphor groups. Columbus, O., H. L. Hedrick, 1928. 23 pp., illus. 24 cm. Thesis (PH.D.)—Ohio State University, 1926.

Goldstein, Israel, Derivatives of 5-aceto carvacryl methyl ether. Relation between molecular structure and odor of 1, 2, 4, 5 substituted benzenes. New York, N. Y., 1927. 24 pp., diagr. 23 cm. Thesis (PH.D.)—Columbia University, 1928.

Hahn, Friedrich Vincenz von, Dispersoidanalyse; die methoden der teilchengrössenbestimmung und ihre theoretischen grundlagen. Dresden and Leipzig, T. Steinkopff, 1928. xxiv, 553 pp. 165 illus., 110 tables (part fold.), diagrs. 23½ cm.

Harris, John McArthur, The activity coefficients of alkali hydroxides in alkali chloride solutions. Philadelphia, 1928. 25 pp., 1 illus., diagrs. 23 cm. Thesis (PH.D.)—University of Pennsylvania, 1928.

Harris, Loyd Ervin, The fatty oil and acids of *Bixa orellana* Linné. Madison, The University of Wisconsin, 1927. 27 pp. 22½ cm. Part of thesis (PH.D.)—University of Wisconsin, 1926.

Houck, Robert Charles, Studies in dyeing. Ithaca, N. Y., 1928. 1 p. l., pp. (161)–186, diagrs. 26½ cm. Thesis (PH.D.)—Cornell University, 1926.

Hutchman, James Edwin, The action of potassium hydroxide on fructose. Columbus, 1928. 13 (1) pp., diagrs. 25 cm. Thesis (PH.D.)—Ohio State University, 1927.

Johnson, Obed Simon, A study of Chinese alchemy. Shanghai, China, The Commercial Press, Limited, 1928. xi pp., 1 l., 156 pp. 21 cm.

Jordan, Charles Bernard, Qualitative analysis for students of pharmacy and medicine, 1st ed. New York, McGraw-Hill Book Company, Inc., 1928. viii, 169 pp. 21½ cm.

Karrer, Paul, Lehrbuch der organischen chemie. Leipzig, G. Thieme, 1928. xxi, 884 pp., illus. 25½ cm.

Kästle, Karl, Untersuchungen über de wirkung einer beimaischung von kartoffeln zu mais auf alkoholausbeute und gärdauer. Giessen Stockach, Druckerei R. Möll, 1927. iv, 61 pp., 2 l. 22½ cm.

Lassar-Cohn, Organic laboratory methods, authorized translation from the general part of 5th rev. ed., by Ralph E. Oesper. Edited by Roger Adams and Hans T. Clarke. Baltimore, The Williams & Wilkins Company, 1928. xi, 469 pp., illus. 24 cm.

Line, Willard Riggs, The amines of magnesium perchlorate and a new method for the determination of ammonia. New York City, 1928. 38 pp., diagrs. 23½ cm. Thesis (PH.D.)—Columbia University, 1928.

Mannheim, Emil, Toxikologische chemie. Berlin und Leipzig, W. de Gruyter & Co., 1926. 135 pp., illus. 16 cm.

Mantell, Charles Letnam, Industrial carbon. New York, D. Van Nostrand Company, Inc., 1928. ix, 410 pp. incl. illus., tables, diagrs., 23 cm. $4.50.

McHenry, Martin Josiah, Smooth platinum wire for electrometric titrations in neutralization reactions. Easton, Pa., 1928. 1 p. l., 11 (1) pp., diagrs. 23½ cm. Thesis (PH.D.)—University of Iowa, 1925.

Morgan, Stanley Owen, The polarization of binary liquid mixtures. Princeton, N. J., 1928. 26 pp., 1 l., illus., diagrs. 24 cm. Thesis (PH.D.)—Princeton University, 1928.

Niederer, Traugott, Studie über die qualitative reinheitsprüfung anorganischer arzneistoffe. Basel, Buchdruckerei E. Birkhäuser & Cie, 1926. 156 pp., 23 cm. Promotionsarbeit—Eidgenöss. tech. hochschule, Zürich.

Noyes, Arthur Amos, An introduction to the chemistry of solutions. Pasadena, 1928. 1 p. l., ii, 48 pp., diagr. 21½ cm.

Oppenheimer, Karl, Lehrbuch der enzyme; chemie, physikalische chemie und biologie. Leipzig, G. Thieme, 1927. ix, 660 pp., diagrs. 25½ cm.

Richardson, Alan Houldsworth, The solubility of oxygen. An analytical method for the determination of the solubility of oxygen under different conditions. New York City, 1928. 47 (3) pp. diagrs. 23 cm. Thesis (PH.D.)—Columbia University, 1928.

Rommel, George McCullough, Farm products in industry. New York, Rae D. Henkle Co., Inc. (1928). xii pp., 1 l., 19–318 pp., 1 l., front., plates. 21 cm. (The first book printed on cornstalk paper.)

Röttger, Hermann, Lehrbuch der nahrungs-mittel-chemie. Leipzig, J. A. Barth, 1926. 2 v., illus., 22½ cm.

Scarth, George William, The elasticity of gelatin in relation to pH and swelling. Montreal, 1925. Cover-title, p. (1009)–1022, diagrs. 27 cm. (McGill University publications. Series II (Botany), no. 34).

Stanislaus, Ignatius Valerius Stanley, and P. B. Meerbott, American soap maker's guide; an up-to-date treatise on the art and science of the manufacture of soaps, candles, and allied toilet preparations. New York, H. C. Baird & Co., Inc., 1928. xi, 709 pp., illus. 24½ cm. $10.00.

Tucker, Elton Brink, Removal of sulfur compounds from petroleum naphthas by catalytic decomposition with bauxite. New York City, 1928. 32 pp., 1 illus., diagr. 23 cm. Thesis (PH.D.)—Columbia University, 1928.

Vail, James Garrett, Soluble silicates in industry. New York, The Chemical Catalog Company, Inc., 1928. 443 pp., illus., diagrs. 23½ cm. (American Chemical Society monograph series, no. 46.)

Magyar chemiai folyóirat. Havi szaklap a chemiai ismeretek fejlesztésére. Budapest, Kir. magy. természettudományi társulat. v., illus., plates, port., diagrs. 25½ cm.

Engines to Run on Heavy Oil Predicted for Near Future. The use of heavier liquid fuels for airplane and automobile engines was forecast in a paper delivered recently before the American Institute of Mining and Metallurgical Engineers by Charles J. Deegan, petroleum engineer of Ponca City, Okla.

A leading automobile manufacturer has on the verge of commercial success a Diesel engine for airplanes weighing only three pounds per horsepower, he declared. The fuel for this engine is a low gravity fuel oil, such as is now used for power purposes and heating. Mr. Deegan raised the question as to what effect the successful use of such an engine in automobiles and airplanes would have on the demand for gasoline.

On the other hand, some oil companies are introducing a light, natural gasoline selling at a higher price than ordinary and capable of being used by both airplanes and automobiles.

More fuel oil than gasoline is being used each day, despite the popular idea that gasoline is the principal product of the distillation of petroleum, Mr. Deegan pointed out. New types of internal combustion engines are likely, in his opinion, to cause the refiners to produce a larger number of different kinds of motor fuels in the future. Whereas only two or three grades of gasoline and one or two of Diesel oil are now manufactured, Mr. Deegan sees the future refinery output consisting of many kinds of internal combustion fuels ranging from very light gasoline to a heavy distillate that approaches the present fuel oil.

Oil companies should spend immediately millions of dollars on chemical research for new products and new processes of refining necessary to meet future demands and provide outlets for the crude oil of future years, Mr. Deegan indicated.—*Science Service*